ATLAS HAND BOOK
ON
CONCRETE CONSTRUCTION

Mrs. R. W. Lesley 6/1/36

The Atlas Handbook

on

Concrete Construction

The Atlas Portland Cement Company

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Foreword

The purpose of "The Atlas Handbook on Concrete Construction" is to provide, in convenient form, practical information on concrete—both plain and reinforced. It is written from the practical rather than the technical standpoint for the average builder in concrete.

Realizing the impossibility of giving in a book of this size detailed information about building many different structures, we have covered in considerable detail, the subjects of concrete, reinforced concrete, and forms, in chapters I, II and III. The builder will be able to adapt this information to the particular work to be handled.

Further information will be gladly furnished. The Technical Department, consisting of a staff of trained engineers is maintained for the purpose of cooperating with builders in concrete.

You are under no obligation for this service. The company furnishes this book and the information and assistance referred to above, without guaranty, warrant or other obligation on its part.

THE ATLAS PORTLAND CEMENT COMPANY
September, 1920

YOUR OPPORTUNITIES IN CONCRETE

The kind of construction to be used often rests with the builder. His advice is sought as to what type of building, roadway, tank or bridge should be constructed. Upon him often rests the responsibility for the type of construction as well as for the proper execution of the work.

You naturally want to serve the interests of those placing their trust in you by selecting the form of construction which will serve them best. Bring to their attention these advantages of concrete construction:

Concrete is fireproof.—It successfully resists severe fires—it cannot burn. When used for buildings, it affords protection against loss of life as well as property.

Concrete is permanent.—It does not rot or decay; therefore it requires no repairs and does not involve expense for painting or other up-keep.

Concrete is strong—and grows stronger with age. This means:

(1) Great load carrying capacity. Reinforced concrete structures have been designed for the heaviest of loads.

(2) Long spans which allow maximum window space with good lighting. Window area in concrete buildings is normally 50 to 85% greater than in other types.

(3) Resistance against vibration. No other type of construction equals reinforced concrete in rigidity.

Concrete is reasonable in cost.—It compares favorably with other forms of construction in original cost, representing lowest cost as compared not only with fireproof buildings, but likewise with mill construction generally.

Concrete means quick construction.—Details of designs are simple and the designs are quickly turned out. Cement and reinforcing steel can be obtained from stock with no waiting for materials. Sand, pebbles and crushed

stone which form the bulk of concrete are usually obtained locally.

Concrete meets architectural and engineering requirements, satisfying all demands as to appearance, utility and economy.

The owner will appreciate your pointing out to him the merits of concrete. He is entitled to a consideration of its advantages.

The structure which you build in concrete will always stand—proof against fire, decay, upkeep and repairs—an enduring monument to your skill and ability as a builder.

CHAPTER I. CONCRETE

The quality of concrete depends upon the materials used, the manner in which they are used, and the way in which the concrete is treated after it is made. The best concrete results only from careful selection and proportioning of materials, proper mixing and placing, and thorough curing.

SELECTION OF MATERIALS

Cement

The only scientifically made ingredient of concrete is the cement. The other materials--sand, pebbles or crushed stone, and water—are used as they come from nature and may vary greatly in quality.

Atlas Portland Cement is a carefully made, thoroughly reliable product, guaranteed to meet all of the requirements of the standard specifications for portland cement. Its quality is definitely established by exhaustive tests before it leaves the mill. It is always uniform and entirely dependable.

The word "portland" signifies only the kind of cement, not the brand. All cements used for important work are portland; the brand name should therefore, always be given. The name "portland" was given to cement by its

discoverer, because of its resemblance, when hardened, to a very hard stone quarried on the Isle of Portland near England.

A barrel of cement weighs 376 pounds net and contains four bags of 94 pounds each, each bag containing approximately one cubic foot. Cement is generally shipped in cloth or paper bags, sometimes in bulk on large jobs, and for export in wooden barrels.

Fig. 1—Atlas Portland Cement
"The standard by which all other makes are measured."

Aggregates

The hard materials, such as sand, pebbles or crushed stone, mixed with the cement to make concrete, are called aggregates. Aggregates are classified as "fine" and "coarse."

Fine aggregate is sand or stone screenings which will pass through a screen with one-quarter inch openings.

Coarse aggregate is commonly pebbles or crushed stone retained on a screen with one-quarter inch openings. The maximum size of pebbles depends upon the character of the work, and usually ranges from three-quarters of an inch to three inches.

Sand—(Fine Aggregate)

Too much care cannot be used in selecting a good fine aggregate. It should consist of clean, natural sand or screenings from hard, durable crushed stone. It should

be composed of quartz grains or other hard material, running in size from fine to coarse.

Sand must be **clean,** otherwise the quality of the concrete will suffer. The impurities that occur in sand are loam, clay, mica and organic matter. Sand containing more than 3% (by weight) of loam or clay should not be used unless washed. Loam can be determined as described on page 5. Mica is very injurious if it occurs to the extent of over 1%.

By organic matter is meant sewage, vegetable matter, tannic acid, manure and other substances of this kind, all of which are very objectionable. Organic impurities can be determined as described on page 5. Sand containing these impurities but meeting requirements of good sand in other respects, can sometimes be used if washed, page 6.

Sand must be **hard,** composed of quartz grains or rock fragments, or other hard material not soft or easily breakable.

A **well graded** sand is better than either a fine or a coarse because it will make a stronger and denser concrete. Fine sand of uniform grain, such as beach sand, is not desirable for concrete. Sand should be graded, i. e., run in size, from fine to coarse with the larger particles predominating.

How to Determine Amount of Loam

Use a pint bottle and put in sand to the height of four inches, then fill the bottle almost full with water. Shake thoroughly and allow to settle over night. The loam and fine material will settle on the top and the thickness of this layer should not be over one-eighth of an inch. See Fig. 2.

How to Determine Organic Impurities*

Fill a 12-ounce prescription bottle with sand to the 4½ ounce mark. Then add a 3% solution of caustic soda known as sodium hydroxide (which you can buy at nearly

*From the Proceedings of the American Society for Testing Materials.

all drug stores) until the volume of sand and solution, after shaking, amounts to 7 ounces. Shake the contents thoroughly and let stand for 24 hours. If the liquid resulting from this treatment is colorless, or has a light yellowish color, the sand may be considered satisfactory in so far as the organic impurities are concerned. If there is a dark colored liquid (above the sand) it indicates that the sand contains organic impurities and must not be used unless these impurities are washed out. See Fig. 3.

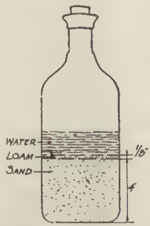


Fig. 2.—Test for Loam.

Fig. 3.—Simple field method of testing sand for organic impurities.

Sand Washing

Sand which is dirty may generally be made suitable for concrete by washing.

A device which can be used advantageously for washing sand or washing and screening bank-run gravel on small jobs is shown in Fig. 4.

Pebbles or Crushed Stone (Coarse Aggregate)

The pebbles or crushed stone must be clean, hard, tough, and graded in size, free from vegetable or other organic matter. The material should be sufficiently hard so that the strength of the concrete will not be limited by the strength of the aggregate. Flat, elongated particles are unsuitable.

The size of the coarse aggregate depends upon the nature

of the work. For thin walls and other construction in which the concrete must be worked around reinforcing steel, the coarse aggregate should run from one-quarter inch to one inch in size. For mass concrete work the coarse aggregate may well run from one-quarter inch to three inches in size. The best concrete results when the pebbles or stone are graded in size. Well graded aggregates, i. e., running in size from fine to coarse, mean stronger and more watertight concrete.

The danger of impurities in pebbles or crushed stone is not nearly so great as in sand. It is very important, however, to make sure that the coarse aggregate is hard and durable.

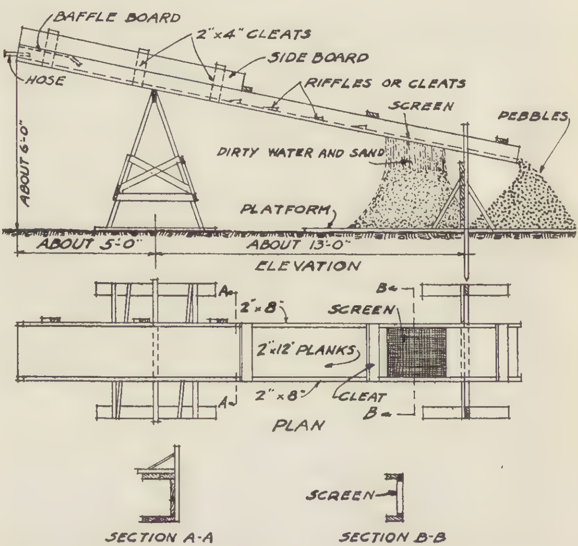


Fig. 4.—A simple washing trough with screen at the lower end, by means of which dirty bank-run material can easily be washed free from clay or other foreign material and the sand separated from the pebbles. The platform on which the sand and pebbles are discharged should be sloped slightly to cause the wash water to flow away freely.

Bank-Run Gravel

In bank-run gravel, the percentage of sand is usually higher than that required in a correctly proportioned mixture, and is liable to vary from time to time. Fig. 5 shows a typical sand bank. The material must, therefore, be screened through a one-quarter inch mesh screen; the sand and pebbles thus separated can then be proportioned in the correct amounts. Washing and screening at the same time may be accomplished by using the device shown in Fig. 4.

Fig. 5.—A typical sand bank containing fine and coarse materia —too great a proportion of sand to gravel for use as bank run. Therefore it should be screened.

Large Stones

In mass work, such as bridge abutments, large stones six inches or more in size are sometimes used to save on the quantity of concrete. The concrete is mixed and placed in the regular way, and the stones are then imbedded in it one at a time, there should be at least six inches of concrete between the stones and the forms. Not over 30% of the mass should consist of such large stones.

Cinder Concrete

The term "Cinder Concrete" is applied to concrete made of cement and cinders. Cinders, in order to be suitable for concrete should be hard, contain no fine ash, and should have been thoroughly wetted at least twenty-four hours before using, so as to slack out any free lime and neutralize the effect of any sulphur present. Household ashes are too fine and powdery and must never be used.

This kind of concrete is employed for certain classes of work, such as cellar walls for dwelling houses or light buildings, for floors that are not designed for carrying heavy loads, and for fireproofing structural steel. The proportion ordinarily used is one part of cement to five parts of cinders. The value of cinder concrete lies chiefly in its cheapness and light weight.

Slag Concrete

Slag, although porous, is a hard material. Due to this hardness and irregular shape, it makes a concrete of high compressive strength. It has been used in concrete work, especially in mass construction with very good results. It is very important that there be practically no sulphur content so as to avoid any detrimental action on the concrete or steel.

Water

Water to be suitable for mixing concrete, must be free from acid, alkali, oil or any other impurity. Sea water should not be used. It is very important to use only **clean** water.

The amount of water is of utmost importance and is treated in the section on Proportioning which follows.

PROPORTIONING CONCRETE

The proportions of concrete materials are always stated by volume, such as 1:2:4, meaning one part of cement, two parts of sand and four parts of pebbles or crushed stone. It must be remembered when using a mixture of sand and pebbles properly proportioned that a 1:4 (one part of cement to four parts of mixed aggregates)—not a 1:6—is the equivalent of a 1:2:4.

For certain classes of work experience has shown that certain mixtures give the best results:

1:2:3 mixture for concrete roadways, one course walks, floors, pavements; some watertight work such as tanks, reservoirs and cisterns; some cast work such as sewer pipe, drain tile and blocks.

1:2:4 mixture for reinforced concrete work such as beams, columns, floors, walls and general reinforced work; for work subjected to water pressure such as tanks, swimming pools, conduits, sewers; for work subjected to vibration such as bridges and engine foundations, for silos, elevators, coal bins.

1:2½:5 mixture for base course for sidewalks, floors and pavements, basement walls not necessarily watertight, foundations, dams, retaining walls and wing walls of bridges and culverts.

1:3:6 mixture for mass construction and large footings and foundations.

If it is desired to determine exactly what mixture, with the materials you have, will give you the densest and best concrete, the principle involved is that of so proportioning the materials as to secure a complete filling of the voids. Sand, pebbles or crushed stone have included in their volume, spaces or voids. In the perfect concrete the voids are thoroughly filled, the proportions being such that the voids in the coarse aggregate are filled by the fine aggregate, and the voids in the fine aggregate are filled by the cement. A certain proportion must be determined

so that this condition will exist so far as possible from a practical standpoint.

It is evident that if the pebbles or crushed stone are graded, containing large and small particles of various sizes, the smaller particles serve to fill the voids of the larger, and less sand is needed; likewise, with a graded sand, less cement is required. Hence, in the use of well graded aggregates, properly proportioned with a certain amount of cement, better strength and density are obtained than with poorly graded aggregates.

A method sometimes used on the job which has proved very successful is that of proportioning by means of maximum density. This is based on the fact that the mixture which would give the least volume for any given quantity of materials represents the densest concrete. Select the proportions which you think will give you the densest concrete and then proportion by weighing all the materials, mixing and measuring the volume. The volume may be measured by using a tin cylinder or iron pail. Repeat this process and a few trials will show which mixture gives the least volume and this mixture represents the densest concrete.

Amount of Water

An excess of water weakens the concrete; an insufficient amount prevents thorough mixing. Water should be measured with the same precision as other materials.

An example of the effect of water is illustrated by the table given below. The tests are at the age of 28 days, using the same mix but varying the amount of water. This table shows that the greatest strength is obtained when the least amount of water is used. It must be remembered however, that too little water can be used and this likewise decreases the strength.

TABLE 1

Gallons of Water for One Bag Batch.	28-Day Compressive Strength Pounds per Square Inch.
5.75	2770
6.0	2600
6.25	2400
6.5	2250
7.0	1950
7.5	1670
8.0	1470
9.0	1100
10.0	830
12.0	480
15.0	200

Using 5¾ gallons of water for one-bag mix, (1 bag cement to 4 cubic feet of uniformly graded aggregate 0 to 1¼″) a strength of 2,770 pounds per square inch is obtained; whereas, when using 10 gallons of water the strength diminishes to 830 pounds per square inch, or in other words, only ⅖ of the strength is obtained.

The injurious effect of water is especially noticeable in the case of concrete walls. Too much water brings a mixture of the floury part of the cement and water to the surface and at the end of the day's work this forms a layer of white material known as laitance. This laitance prevents the proper bonding of more concrete placed thereon and constitutes a plane of weakness. It is especially injurious if it occurs in tanks or dams, where water-tight construction is necessary. When laitance forms it should always be removed by scraping before new concrete is placed.

The importance of the water content in concrete can not be over emphasized and the best contractors are using the minimum amount of water consistent with allowing the concrete to be properly transported and deposited in the forms.

Slump Test

The consistency of concrete or, in other words, the amount of water to be used, may be determined by means of what is known as a slump test. This is really very simple. It consists of a sheet iron cylinder six inches in diameter and twelve inches high, so arranged that it can be lifted straight up without any sidewise pull.

It is set on a piece of sheet metal which forms the bottom, and is filled with concrete, then thoroughly tamped. Immediately thereafter the cylinder is raised by means of a windlass, shown in Fig. 6. The reduction in the height of the pile of concrete upon removal of the cylinder is the amount of slump. Concrete such as is used for ordinary reinforced concrete work shows a slump of 8 to 9 inches; that is, a 12-inch cylinder of concrete is only 3 or 4 inches high after the removal of the cylinder.

For certain classes of work where concrete does not need to be made so wet on account of pouring and working around reinforcement, the allowable slump is much less, 4 inches being about the right amount for ordinary plain concrete work such as floors, sidewalks, driveways, footings and basement walls.

Fig. 6.—Making the Slump Test.

TABLE 2

Materials for One Cubic Yard of Rammed Concrete Based on Using Pebbles or Crushed Stone with Dust Removed

Mixture.	Bbls. Cement.	Cu. Yds. Sand.	Cu. Yds. Pebbles or Stone.
1:1½:2½	2.09	0.46	0.77
1:1½:3	1.91	0.42	0.85
1:2:3	1.74	0.52	0.77
1:2:3½	1.61	0.48	0.83
1:2:4	1.51	0.45	0.89
1:2½:4	1.39	0.51	0.82
1:2½:5	1.24	0.46	0.92
1:3:5	1.16	0.52	0.86
1:3:5½	1.11	0.49	0.90
1:3:6	1.06	0.47	0.94

(From Taylor & Thompson's "Concrete, Plain and Reinforced".)

TABLE 3

Average Weights of Aggregates Used for Concrete

Size 1½ inch down to ¼ inch—dust screened out.

	Lbs. per Cu. Yd.
Sand	2700
Pebbles	2800
Limestone	2400
Granite	2500
Trap Rock	2700

TABLE 4

Average Weight per Cubic Foot of Concrete in Place

	Pounds.
Gravel Concrete	150
Limestone Concrete	148
Trap Rock Concrete	155
Cinder Concrete	112

TABLE 5

Typical Compressive Strength Test of Concrete using a good grade of commercial aggregates and a medium consistency, in pounds per square inch:

Mixture.	7 Days.	28 Days.	6 Months.
1 : 1½ : 3	1600	2700	3700
1 : 2 : 4	1100	2100	3000
1 : 2½ : 5	800	1600	2100
1 : 3 : 6	500	1300	1800

These tests are obtained under laboratory conditions; field tests would be somewhat less.

TABLE 6

Covering Capacity in Sq. Ft. of 1 Bbl. Cement in Various Mixes of Mortar

Mixture.	Thickness in Inches.				
	¼	⅜	½	¾	1
1 : 1	259	173	129	87	65
1 : 1½	324	216	162	108	81
1 : 2	392	262	195	132	98
1 : 2½	456	304	228	152	114
1 : 3	524	350	262	175	131
1 : 3½	588	392	294	196	147
1 : 4	656	438	327	219	164

TABLE 7

Covering Capacity in Sq. Ft. of one Cubic Yd. of Sand in Various Mixes of Mortar

Mixtures.	Thickness in Inches.				
	¼	⅜	½	¾	1
1 : 1	1830	1220	914	610	457
1 : 1½	1542	1028	772	515	386
1 : 2	1393	928	697	464	348
1 : 2½	1296	864	648	432	324
1 : 3	1234	822	617	411	308
1 : 3½	1200	800	600	400	300
1 : 4	1168	780	584	389	292

TABLE 8

Quantities of Cement and Sand required for 1 Cu. Yd. of Mortar.

Mixtures.	Cement, Bbls.	Sand, Cu. Yds.
1 : 1	4.88	0.72
1 : 1½	3.87	0.86
1 : 2	3.21	0.95
1 : 2½	2.74	1.01
1 : 3	2.39	1.06
1 : 3½	2.12	1.10
1 : 4	1.90	1.13

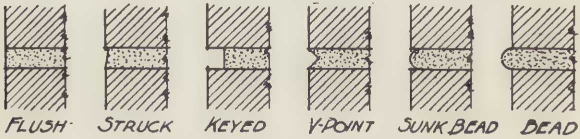


Fig. 7.—Sections of Mortar Joints.

QUANTITIES OF CEMENT MORTAR FOR BRICK AND HOLLOW TILE WORK

The mortar commonly used for laying brick, tile and stone is made of 1 part cement and 3 parts sand. For white joints Atlas White (see page 143) is used with white sand or white crushed marble in the above proportions. If colored joints are desired coloring matter is added to the mortar. Hydrated lime may be added if desired. Many contractors prefer to use lime because it makes the mortar work more easily under the trowel and allows it to spread better. The amount of lime to be used runs from 10% to 20% by volume of cement, and should not exceed 20%. The size of joint generally used is from 3/8″ to 1/2″. Different kinds of joints are shown in Fig. 7.

Brick work is estimated by finding the number of square feet of wall surface and allowing 21 common brick per square foot for a wall 13 inches thick. The other thicknesses of wall are figured in proportion. Contractors give figures ranging from 675 to 800 brick to a barrel of cement, or an average of about 750.

The following table shows the amount of cement and sand required for laying brick and tile for joints of average 3/8 inch thickness:

TABLE 9

	Barrels Cement Required per 1000.	Cu. Yds. Sand Required per 1000.
Common Brick	1 1/2	5/8
3 x 12 Hollow Tile	4 3/4	2 1/8
6 x 12 Hollow Tile	6 1/2	2 7/8
8 x 12 Hollow Tile	7 1/2	3 1/8

To prevent mortar drippings from adhering to brick, dip the face of the brick before laying, in a soft soap solution.

THE STORING AND HANDLING OF CEMENT, SAND AND STONE

Careful storage of materials pays. Even on small jobs many tons of concrete materials must be unloaded, stored, placed in the mixer, elevated and distributed. If one handling can be eliminated, or if only a few cents a ton can be saved through proper arrangement, the result will be very noticeable in the profit or loss record.

Although on a small or medium size building job it does not pay to lay out an elaborate storage and handling plant, some attention should be given to selecting convenient locations for various materials.

Cement

The first thing in connection with the storage of cement on the job is to keep it **absolutely** dry. If the job is to last over two weeks, it is a good plan to provide a dry weathertight storage shed at some convenient location. Where the concreting will be finished in one or two weeks a temporary shelter such as shown in Fig. 8 may be built

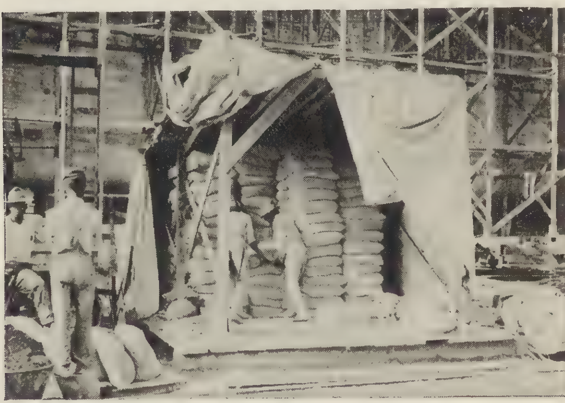


Fig. 8.—Shelter for cement at mixer. Capacity about 250 bags. Roof of slats and tar paper; canvas sides. Note floor raised off ground on mud-sills.

at the mixer. This holds about 250 bags of cement, which provides ample reserve in case any delay should occur in hauling. It is the practice, however, to make the shelter much smaller and in some cases to merely provide a tarpaulin in case of rain to throw over the 20 or 30 sacks which are kept at hand. A small second-hand army tent can be used to advantage as a shelter.

Cement **must be kept off the ground** no matter what arrangements are made for its storage.

For handling cement in bags from storage house to mixer a two-wheel warehouse hand truck is best for distances up to about 200 feet. An average truck-load is 4 to 6 bags.

Sand and Stone

In order to cut down length of wheelbarrow runs, the sand and stone piles should be located close to the mixer (Fig. 9). Since in the majority of cases about twice as much stone is used as sand, the stone pile should be located closest to the mixer. Where there is plenty of room, the sand and stone is stored in low piles just as dumped from the bottom-dump or end-dump wagons or trucks.

Where space is at a premium, temporary wooden bins allow the materials to be piled higher and confined to a smaller ground space. For most ordinary jobs this is not justified, unless storage space is unusually limited.

Fig. 9.—Stone and Sand Piles with Runway to Mixer.

The Atlas Portland Cement Company will be glad to send you suggestions on storage bins and on economical storage and handling of materials for larger work than treated in this book.

MIXING AND PLACING

Hand mixing is resorted to only when a very small quantity of concrete is to be mixed. For even small jobs a good mixer represents economy in labor and better quality concrete.

Mixer

The mixer should be of batch type with a capacity of at least a one-bag batch of 1:3:6 concrete. Such a mixer is usually rated at a capacity of 10 cubic feet of loose material. A mixer of this size will take a one-bag or a one and one-half bag batch of 1:2:4 mixture. However, it is well to avoid when possible a split-bag batch, since using part of a bag tends to lead to inaccuracies in proportioning.

Fig. 10.—Concrete Mixer charged by elevating skip into which the barrows dump. Note that this means that sand and stone are wheeled on a level.

The next size larger mixer is one having a capacity of 15 cubic feet of loose material—the equivalent of a two-bag batch of 1:2:4 mix. This is an ideal size for average construction work.

All things considered, an elevating loader-skip is a good help to most mixers.

Fig. 11.—Small Gasoline-Driven Mixer of capacity of 10 cu. ft. of unmixed material. Will take 1-bag batch of any proportion up to 1 : 3 : 6.

Water Supply

The water supply for the mixer should come through a 1½-inch pipe, or better, a 2-inch pipe. Not only is it extremely important from the standpoint of securing good concrete, that the amount of water and therefore, the consistency of each batch should remain uniform, but also

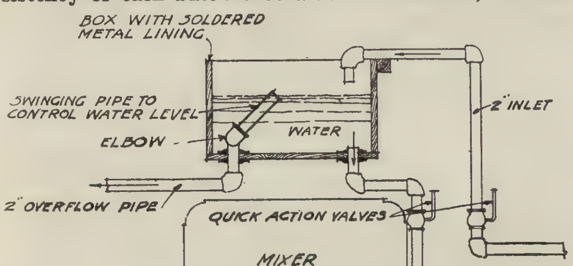


Fig. 12. Water Measuring Device for Mixer

from considerations of economy and increase of mixer output. Hence, some means of securing a regulation of the amount of mixing water per batch is very desirable. (Fig. 12.)

Many concrete mixers may be purchased equipped with an automatic water measuring drum attached permanently to the mixer. These are so arranged as to allow just the required amount of water to flow into the tank for each batch and hence there is uniformity.

Mixing

For charging the mixer a wheelbarrow is ordinarily used. The ordinary wheelbarrow load of sand or stone is 2 cubic feet. A deeper barrow is on the market which holds 4 cubic feet, and these sometimes are used although rarely filled with over 3 feet of material. Fig. 13 shows bottomless measuring box which makes correct amounts of materials a certainty.

In table 10 are given the dimensions for bottomless measuring boxes of various capacities.

Where wheelbarrow measurement of sand and gravel is to be permitted, the capacity of the wheelbarrow should first be found out by the use of a measuring box.

To obtain uniform loads the wheelbarrow measurement should be checked up occasionally by throwing the box onto the wheelbarrow and filling the barrow with a measured quantity.

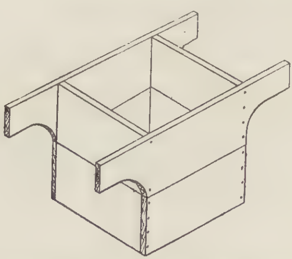


Fig. 13.—Measure stone in bottomless measuring box. Accuracy is secured by this method.

TABLE 10.
Dimensions for Bottomless Measuring Boxes of Various Capacities.

Capacity in Cubic Feet.	Inside Measure.		
	Length Inches.	Breadth Inches.	Height Inches.
1 Cubic Foot........	12	12	12
1¼ Cubic Foot........	15	15	9⅝
1½ Cubic Foot........	15	15	11½
1¾ Cubic Foot........	15	15	13½
2 Cubic Feet.........	18	18	10⅝
2¼ Cubic Feet.........	18	18	12
2½ Cubic Feet.........	18	18	13⅜
2¾ Cubic Feet.........	18	18	14⅝
3 Cubic Feet.........	18	18	16

It is advisable to have one box for sand and two for stone and have each marked plainly "sand" and "stone."

Concreting Gang

The following paragraphs are not intended for definitely specifying the size of the gang for each job. Only a basis is given for estimating the organization needed for the average or medium size job. Let us assume that a 1-bag batch of 1:2:4 concrete is to be mixed. Then we need 1 barrow of sand and 2 barrows of stone for each mix. This means three wheelers, and unless the distance from the sand and stone piles to the mixer is very short it is a good plan to have two extra shovelers.

At the mixer if it is gasoline driven, we need one man to attend to the engine, discharge the mixer and act as a general mixer foreman. One man attends to dumping in cement and regulating water and one man to bringing up cement to the mixer, sorting and bundling empty bags, etc.

For distributing the concrete it is difficult to determine beforehand just how many men will be needed—it all depends on how far the concrete must be wheeled and how easily it can be dumped into place. Three wheelbarrows will take care of each batch, but it probably will be necessary to have extra barrows so that there will be no mixer delay.

Considering all these points we find that an average concreting gang would consist of about the following:

Charging mixer—
- 2 wheelers on stone (possibly 1 loader).
- 1 wheeler on sand (possibly 1 loader).

At mixer—
- 1 engineer or mixer foreman.
- (If steam driven, add 1 fireman).
- 1 cement and water man.
- 1 man bringing cement to mixer (probably 1 additional on sorting bags, etc.).

Distributing concrete—
- 3 wheelers (possibly more, dependent on length of wheel).
- 1 man helping to dump barrows.
- Extra men shoveling, tamping, spading, etc., depending on character of work.

Total, approximately 12 men.

Output of Concrete

For conservatively estimating output, an average time for each batch should be from 2 to 3 minutes. This means actual mixing of at least one minute. Table 11 gives output for various proportioned batches on this assumption.

TABLE 11
Hourly Output of Concrete for Various Proportions
Based on average time per batch

Proportions 1-Bag Batch.	Aver. Time per Batch 2 Minutes.	Aver. Time per Batch 3 Minutes.	Aver. Time per Batch 4 Minutes.
	Cubic Yards.	Cubic Yards.	Cubic Yards.
1 : 1½ : 3	4.0	2.6	2
1 : 2 : 3	4.3	2.9	2.2
1 : 2 : 4	5.0	3.3	2.5
1 : 2½ : 4	5.4	3.6	2.7
1 : 2½ : 4½	5.7	3.8	2.9
1 : 2½ : 5	6.0	4.0	3.0
1 : 3 : 6	7.1	4.7	3.5

For a two-bag batch multiply quantities by 2, and for three-bag batch multiply by 3, etc. Of course, a larger batch will require more men supplying the mixer.

Taking an average time per batch of 3 minutes, which is fair for the medium size job, the output of the gang listed on a 1-bag, 1:2:4 mix would be 26.4 cubic yards for an 8-hour day.

TABLE 12

For Use in Computing Daily Yardage of Concrete Mixed and Placed

Proportions.	Amount of Concrete in a 1-Bag Batch.	
	Cubic Feet.	Cubic Yards.
1 : 1½ : 3	3.53	.131
1 : 2 : 3	3.90	.145
1 : 2 : 3½	4.22	.156
1 : 2 : 4	4.50	.167
1 : 2½ : 4	4.88	.181
1 : 2½ : 4½	5.17	.192
1 : 2½ : 5	5.44	.202
1 : 3 : 5	5.81	.215
1 : 3 : 5½	6.11	.226
1 : 3 : 6	6.38	.236

Example: Your mixer has turned out 164 two-bag batches of 1:2½:5 concrete and you want to know how much this amounts to in cubic yards. The table gives .202 cubic yards for a one-bag batch, so we multiply .202 by 2 to give us the quantity for a two-bag batch, and this by 164 batches to get the total yardage. Thus: .202 x 2 x 164 = 66.2 cubic yards.

Placing

For the small or medium size job handling the concrete must meet one of two general conditions:

1. Where concrete is deposited below, or at about the same level as the mixer.
2. Where concrete must be elevated above the mixer level: for instance for walls and floors above ground.

For the first condition, no special arrangement need be made, the concrete being discharged directly from the mixer into wheelbarrows or carts—"concrete buggies." (A concrete buggy is shown in Fig. 14). The concrete is then wheeled along plank runways to the proper point and dumped into place. Where the concrete is to be placed in foundations or footings below ground level, simple board chutes may be used for chuting it into place. Such chutes are made with a flared upper end for convenience in dumping the barrow or buggy directly into them.

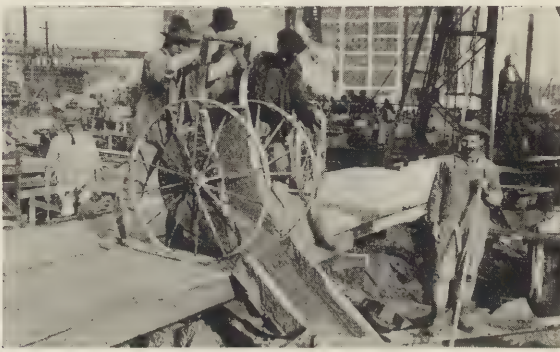


Fig. 14.—Concrete Cart or "Buggy" of 6 cubic feet capacity. Much superior to ordinary barrow for handling concrete.

For the second condition, where the concrete must be elevated, some special provisions are made. Where the job is a one-story building, such as a garage, dairy barn or store building, and the concrete must be elevated not more than 10 or 15 feet above ground level, inclined runways for wheeling the concrete up to the required elevation are simple and reasonable in cost, especially if only a small amount of concrete is to be handled. Wheelbarrows of 2 cubic feet capacity are used, the larger concrete buggies being too heavy. In order to cut down the slope, runways are often built with one or two returns. On

some very small jobs where only a few yards are raised a few feet, it pays to use ordinary hand pails to pass up the concrete.

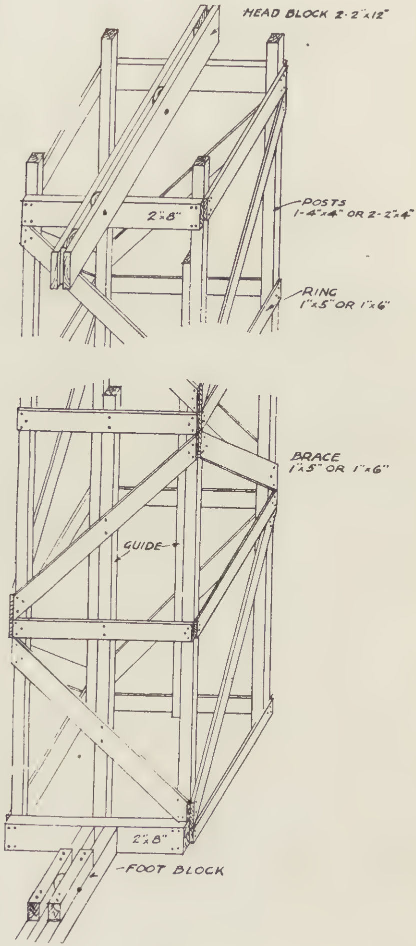
For the majority of jobs a hoist of some sort will be needed.

A standard concreting hoist tower is shown in Fig. 15. This is made of wood by your own carpenters and can be used over and over again, if well cared for. A chute for discharging from the mixer into the bucket is shown in Fig. 16. Such a tower may be used not only for hoisting concrete but by replacing the concrete bucket with a platform, may be used for elevating other materials as well.

Some contractors prefer to eliminate the concrete bucket by using a platform hoist for elevating the barrows one at a time. This is simple and less expensive as it requires no outlay for a bucket, but is not good policy where it is expected to keep the mixer running constantly at capacity, since the concrete could not be taken away fast enough. Fig. 17 shows a platform hoist.

A simpler rig for use where only small quantities are to be elevated one or two stories is shown in Fig. 18. This consists of two light truss members, one at each side, with a cross member supporting the hoisting sheave at the top. X-bracing and vertical planks between the two side members serve as a guide to the bucket. Stops at the top catch the lip of the bucket and tip it, thus discharging its contents into a hopper or chute.

A device sometimes used for hoisting small quantities of concrete only one or two stories, as well as other material, is the jib-crane (Fig. 20). This is very useful when equipped with a small tip-bucket, or an improvised bucket made of a large can or small steel barrel. Since the bucket can be unhooked in a few seconds, bundles of reinforcing bars, lumber for forms and other such materials can be sent up with little delay to the concreting gang. Do not try to send up too much concrete at a time with this—at the most 3 or 4 cubic feet will be a large enough load to send up safely.



F.g. 15.—Hoist Tower. (See Fig 15A).

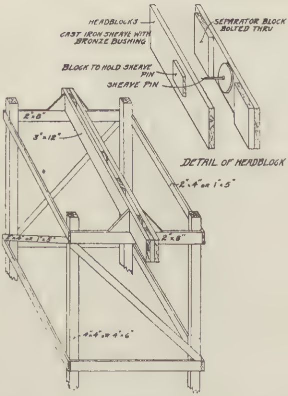


Fig. 15A.—Detail of Top of Hoist Tower.

The jib-crane in the form described, or a variation of it, is extensively used in silo construction, for hoisting the concrete. With some of the commercial steel forms the central steel mast that supports the forms also serves as the mast for the jib-crane.

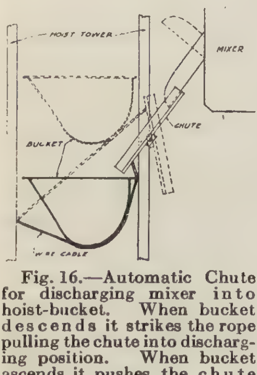


Fig. 16.—Automatic Chute for discharging mixer into hoist-bucket. When bucket descends it strikes the rope pulling the chute into discharging position. When bucket ascends it pushes the chute back out of the way.

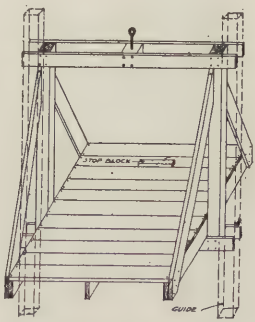


Fig. 17. — Platform Hoist for Wheelbarrow.

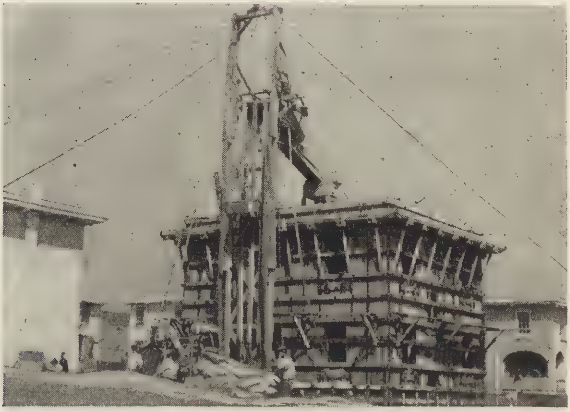


Fig. 18.—Semi-Portable Concrete Hoist. Guys hold it in position slightly inclined from vertical, so that bucket slides up in contact with plank guides.

Hoisting Machinery

With any of the elevating equipment described, some means of hoisting must be applied. For the regulation tower a single drum hoist is needed of sufficient power to take the bucket fully loaded quickly to the tower-top. Many mixers are provided with a friction-drum and sufficient extra power to operate it.

Since these drums are generally furnished with the smaller gasoline mixers, it should be borne in mind that they are not designed for very heavy loads. If the work requires a lift of three stories or more, it is best to have a separate hoist.

There are a number of simple and reliable single-drum gasoline hoists on the market. Fig. 19 shows this type of hoist. These are ideal for small and medium sized jobs and should form a part of the equipment of every contractor.

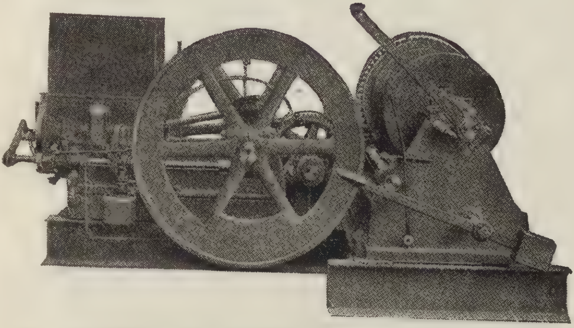


Fig. 19.—Single Drum Gasoline Hoist. Various capacities from 1,200 to 3,000 pounds.

Many jobs, such as silos, small elevated water tanks, etc., call for so small a quantity of concrete that it does not pay to bring a power hoist to the work. The combination of a jib crane (Fig. 20) and a horse will solve the problem. No more than 3 cubic feet of concrete (450 pounds) should be sent up at one time. It is advisable to have some form of brake, such as shown in Fig. 21 to control the descent of the bucket.

When a concreting tower and tip-bucket are employed, an elevated discharge hopper must be provided as shown in Fig. 22. This hopper is made on the job, but there are on the market steel hoppers which may be used in the same way.

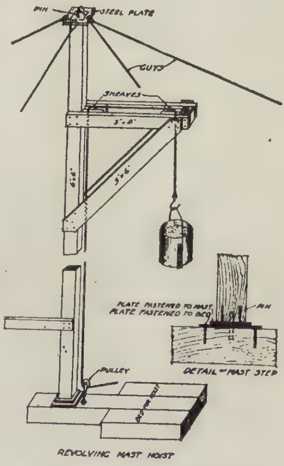


Fig. 20.—Revolving Mast Hoist.

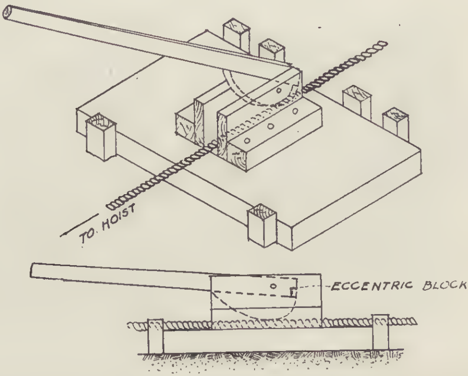


Fig. 21.—Brake for Hoist Rope used with Horse for Power.

From this hopper, or from the bucket if one of the simpler devices is used, the concrete is discharged into wheelbarrows or concreting carts for transporting to the point of placing. For the larger jobs a system of steel chutes often is used, but this would not pay on a small or medium size job.

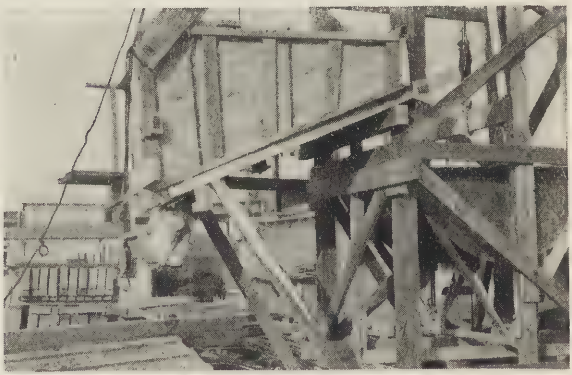


Fig. 22.—Floor Discharge Hopper for use with Hoist Tower.

WATER-TIGHT CONCRETE

The methods employed in making concrete water-tight may be classified as follows:

(1) Accurately grading and proportioning the materials so as to secure maximum density;

(2) Special treatment of the surface by plastering or washing after the concrete has hardened;

(3) Mixing compounds with the concrete—known as the integral method;

(4) Application of layers of waterproof material such as asphalt and felt to the concrete, known as the membrane system.

I. Accurate Grading and Proportioning of Materials

It is an established fact that an impermeable concrete can be made by the use of good, clean, well-graded aggregate so proportioned with the cement as to secure maximum density. Following is a quotation from Technologic Paper No. 3, by the Bureau of Standards, Department of Commerce and Labor, Washington, D. C.:

"Portland cement mortar and concrete can be made practically watertight or impermeable (as defined above) to any hydrostatic head up to 40 feet without the use of any of the so-called 'integral' waterproofing materials; but, in order to obtain such impermeable mortar or concrete considerable care should be exercised in selecting good materials as aggregates, and proportioning them in such a manner as to obtain a dense mixture. The consistency of the mixture should be wet enough so that it can be puddled, the particles flowing into position without tamping. The mixture should be well spaded against the forms when placed, so as to avoid the formation of pockets.

"The addition of so-called 'integral' water-

proofing compounds will not compensate for lean mixtures, nor for poor materials, nor for poor workmanship in the fabrication of the concrete. Since in practice the inert integral compounds (acting simply as void filling material) are added in such small quantitites, they have very little or no effect on the permeability of the concrete. If the same care be taken in making the concrete impermeable without the addition of the waterproofing materials as is ordinarily taken when waterproofing materials are added, an impermeable concrete can be obtained."

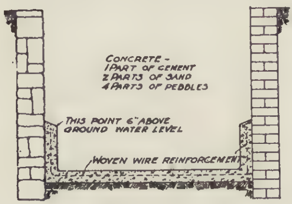


Fig. 23.—Method of Waterproofing Old Cellars of Brick or Stone.

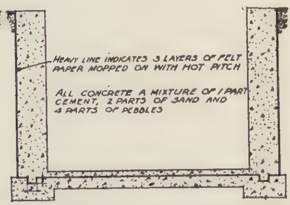


Fig. 24.—Method of Waterproofing Cellar against Ground Water.

II. Special Treatment of Surface

The second method involves the treatment of the surface, dealing with the use of a cement mortar or wash of some kind, applied to the surface of the concrete after the removal of the forms. The concrete is first cleaned and roughened so as to insure a proper bond. All dirt or grease must be removed as the presence of these substances on the concrete prevents the adhesion of the mortar. A stone pick or similar tool should be used to roughen the surface thoroughly, then the concrete drenched with water, and the mortar applied to a thickness of $\frac{5}{8}$ to 1 inch. This is generally done in two coats applied at intervals of 24 hours. The first is a scratch coat which should be thoroughly roughened with a stick or trowel before it has set, and the second coat is applied and brought to a smooth finish with a trowel. A good mixture is one

part Atlas Cement, two parts clean, coarse, well-graded sand, and one-tenth part hydrated lime.

A successful method for securing a dense impervious surface for such work as water tanks, cisterns and well linings, is the application of ordinary parafine to the inside surface of concrete, after it has hardened. The surface should be thoroughly clean and perfectly dry. Hot parafine is brushed on and then driven into the pores of the concrete with the flame of a gasoline blow-torch. The parafine penetrates the surface. Greatest penetration is secured when the concrete is warm, as in the summer time.

Another surface treatment consists of the application of asphalt or other bituminous material. The asphalt is dissolved in gasoline or benzine and the resulting liquid brushed on. The gasoline carries the asphalt into the pores of the concrete and then evaporates, leaving the asphalt. This treatment darkens the surface of the concrete.

III. Integral Method

The third method involves the mixing of some material with the concrete, which acts as a void filling substance. Hydrated lime is being used successfully for this purpose. Ten per cent of hydrated lime based on the volume of the cement, makes the concrete denser and more watertight, and this amount does not cause any appreciable loss in the strength of the concrete. Instead of the hydrated lime, many contractors figure that the use of additional cement in the mix is the most economical and satisfactory way of securing watertight concrete. Just add 10% to 20% extra cement, depending on the water pressure. There are integral waterproofing compounds marketed by different manufacturers which are also used for the purpose of rendering concrete waterproof.

IV. Membrane System

The membrane system of waterproofing is the coating of the surface of the concrete with an asphaltic or other

coat which is of itself waterproof. This can usually be done on only the side of the wall from which the water pressure comes. (See Fig. 24.)

Two coats of hot asphalt or coal tar thoroughly swabbed on the wall are commonly used. For very particular work, successive layers of asphalt and felt or burlap are used.

If you have any problem in waterproofing either in structures already built or to be built, the Atlas Portland Cement Company will be glad to have you take the matter up with them.

CONCRETING IN COLD WEATHER

Concrete work can be done successfully, in cold weather by observing a few simple rules. In making and placing concrete with the temperature below 35 degrees Fahrenheit, keep the concrete from freezing until it has become thoroughly hardened. Freezing is prevented by (1) Heating the materials, (2) protecting the fresh concrete from the cold.

Water for mixing may be heated in the water barrel, or supply tank, by a coil of pipe through which passes exhaust or live steam. There are also devices for heating the water by direct contact with steam as it passes through a mixing valve. On small jobs a large kettle or caldron with fire beneath is employed. Water is usually heated to about 150 degrees.

Fig. 25—Heating the Aggregates

One method of heating the sand and stone is by embedding a discarded sheet iron pipe in the piles (Fig. 25). A wood fire in the pipe furnishes the heat. Sand and stone are sometimes heated by steam coils or by thrusting one or more steam pipes into piles of material. The steam pipes are drawn down to a small opening at the end so as not to pass too much steam. Some prefer to perforate the steam coils with a number of small holes to allow the steam to pass out. As the steam rises through the sand and stone it effectually heats the particles. Canvas may be stretched over the tops of the material piles to prevent the too rapid escape of the steam.

Fig. 26.—Concrete Pavements for sidewalks, driveways or yards may be laid during cold weather by housing in, as here shown and keeping the enclosure at proper temperature by using salamanders.

All fresh concrete must be protected immediately upon being placed in the forms. This suffices for large mass-work or where temperatures are not very low; canvas and a thick layer of hay or straw should be used as a covering. For small concrete members or thin floors where the mass of concrete is small, it is customary to enclose the work with building paper or canvas and heat the interior by means of "salamanders" (sheet iron stoves). It is now

the usual practice to enclose with canvas, reinforced concrete buildings and keep the interior temperature well above freezing by the use of salamanders. Fig. 26.

For winter work forms must be left in place a longer time than with summer temperatures. Further details on winter work may be obtained by sending for "Concreting in Winter."

Fig. 27.—Covering Concrete with Straw for Protection.

CONCRETING UNDER WATER

To obtain good concrete, when it must be placed under water, it is necessary to get the concrete in place without giving the water a chance to separate the aggregates and cement.

The simplest and probably best method is to use a "tremie" (Fig. 28). This is a sheet iron cylindrical chute with a hopper at the top. It is open at both ends. The cylindrical portion should be large enough to hold an entire batch of concrete and long enough to extend from just above the water level to the bottom of the excavation to be concreted. The "tremie" is placed in the water and filled with concrete. It is then raised slowly just far enough to allow part of the concrete to escape through the open bottom and spread into place. The lower end of the pipe should never be emptied of concrete. This will prevent the entrance of water from the bottom.

When only a small amount of concrete is to be placed, it can be shoveled into a length of stove pipe used in much the same manner as a "tremie." This is simply and easily done. First put the pipe in position and fill it full of concrete to expel the water. Then gradually lift it a little each time you put in a batch.

All concrete placed under water should be mixed as dry as possible to reduce the danger of separation of the concrete materials.

Concrete under water has a greater tendency to form a scum or laitance than concrete above water. For this reason a mass of concrete under water should be poured in one operation, though it may require both day and night work. Otherwise, there will be laitance seams which will greatly reduce its strength. Walls that are partially under water should have the wall brought above the water level before the concreting is stopped. Provision can then be made for building the rest of the wall at a later date by placing bonding bars or stones in the top of the wall, care being taken to remove the laitance.

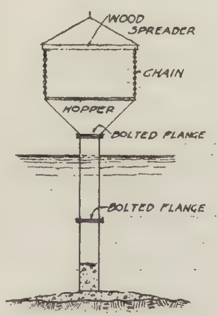


Fig. 28.—Hopper and Chute or "Tremie" Method.

BONDING CONCRETE OR MORTAR TO CONCRETE ALREADY IN PLACE

The bonding of concrete surfaces is divided into two classes: finishes on vertical surfaces, such as stucco work and cement mortar plastering,—and horizontal surfaces such as floors and sidewalks.

Vertical Surfaces

If the forms are removed as soon as the concrete can bear its own weight, the surface film can be removed by brushing with a heavy wire brush. Better results can be sometimes obtained by using a sharp pointed tool. If the forms have been greased, the walls should be washed down thoroughly with a solution of one part muriatic acid and four parts of water. Then all trace of the acid must be removed by thorough washing. When the mortar coating is to be put on, thoroughly drench the wall with water, and before the mortar is applied, brush the surface with a creamy mixture of cement and water.

Horizontal Surfaces

Bonding horizontal surfaces usually consists of placing the finishing coat on floors or sidewalks, or pouring concrete for walls on successive days.

If the concrete has hardened, the surface must be thoroughly cleaned, roughened and wetted. Then apply a creamy mixture of cement and water and follow immediately with the topping if a floor or sidewalk, or additional concrete if a wall.

CURING CONCRETE

If the forms are allowed to stay in place for several days they will provide sufficient protection. If they are removed while the concrete is still green, protection should be provided by covering with canvas or burlap, or sprinkling, which will prevent drying too rapidly. Too rapid drying out is liable to cause cracks and a weakened concrete. The presence of sufficient moisture during the

early hardening period of ten days or two weeks will greatly increase the strength of the concrete.

As an illustration concrete road specifications require that the concrete be first protected by covering with canvas and then as soon as there is no danger of pitting, that the concrete be covered with dirt and kept wet for a period of ten days. Such specifications strongly emphasize the importance of proper curing of concrete because it is realized that the strength and resistance to wear depend so greatly upon this.

SURFACE FINISHES

A good surface finish adds to the attractiveness and hence to the value of the structure. There are several different finishes for concrete.

For ordinary construction a smooth, dense surface, free from cavities is sufficient. Cavities can be prevented by spading and churning the concrete as it is poured and by pounding the forms with wooden mallets to force back the coarse aggregate from, and bring the mortar to, the surface of the form. (Fig. 29.)

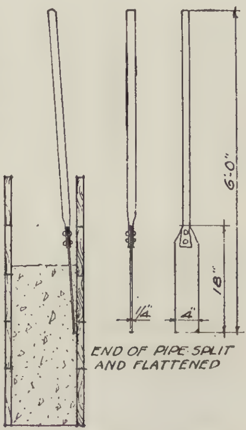


Fig. 29.—Spading Concrete.

The washed or scrubbed finish is attractive and easily handled. It is obtained on the spaded or mortar faced surface, by using a stiff fibre or wire brush with plenty of water when the concrete is still green. The forms must be removed in about twenty-four hours in order that the surface may be effectively treated. If too green, the

aggregate will break out and if allowed to harden too long the work cannot be done effectively. The washing of the surface should be continued until a uniform texture results. (Fig. 30.)

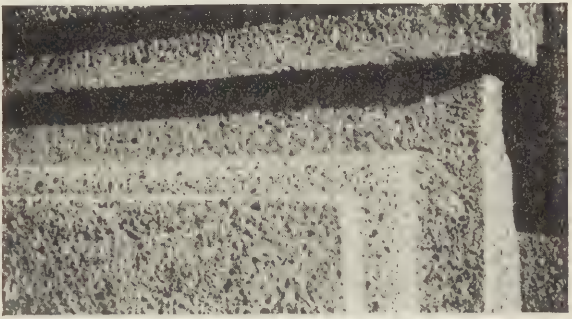


Fig. 30.—Surface Finish Obtained by Washing.

The rubbed surface is common and very satisfactory. By spading the concrete as above described and lightly pounding the forms with a wooden mallet an even surface next to the forms is secured. While the concrete is still soft and moist—(rubbing should be done within 24 hours after pouring if possible to remove forms)—rub this sur-

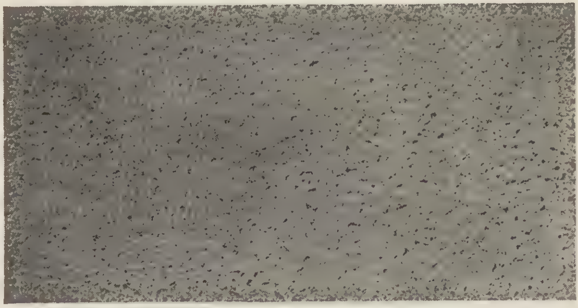


Fig. 31.—Concrete Surface finished by rubbing with Carborundum Block.

face with a wooden float on which is placed from time to time coarse sand and water, or use a hard brick dipped in water. If there are pockets they should be filled during rubbing with a 1:2 mortar. If the concrete has hardened the form marks and fins left by the boards can best be removed by rubbing with a carborundum block. (Fig. 31.)

Fig. 32.—Surface Finish obtained by Tooling.

Tooling may be done either by hand tools, such as picks and bush hammers, or by pneumatic hammers, and very satisfactory results are obtained. This process may be used on either the spaded surface or mortar facing; the best results are secured on the latter. The concrete should be at least thirty days old. It must be well hardened and should be older for pneumatic hammering than for hand-tooling. (Fig. 32.)

A "dash" finish coat can be applied directly to the surface of concrete. A creamy mixture of 1:2 Atlas-White Cement and sand is thrown on with a stiff brush, so as to thoroughly cover the concrete surface. This produces a very attractive finish at small cost. (Fig. 33.)

Stucco when applied to concrete makes a very satisfactory surface finish. It is of utmost importance that the concrete be properly prepared by roughening, cleaning and wetting, so that the stucco will adhere firmly. If the forms are removed within 24 hours the surface of the concrete can be scraped with a wire brush, so as to remove the surface film. If it is necessary to leave the forms on for a longer time the surface can be roughened by means of a stone pick or similar tool. All loose particles should then be entirely cleaned off and the concrete should be thoroughly drenched with water.

Fig. 33.—Applying Dash Finish.

Stucco is a mixture of cement, sand and water, with or without the addition of hydrated lime; in other words, it is a cement mortar. The mixture suggested is one part cement, three parts sand and one-tenth part hydrated lime.

A large variety of surface finishes are possible, such as smooth, rough, stippled, splatter-dash and exposed aggregate. The use of Atlas-White with color aggregates, such as colored sands, colored crushed marble or crushed granite, allows a wonderful variety of color effects. The color combinations and textures are practically unlimited. These effects are obtained by throwing the aggregates on the fresh mortar as soon as applied and pressing them in with a wooden float, or by mixing the aggregates in the mortar and then exposing by washing.

Stucco is also applied to concrete blocks, hollow tile, brick, metal and wood lath. Further information on stucco with specifications will be gladly furnished you by the Atlas Portland Cement Company.

CHAPTER II. REINFORCED CONCRETE

Reinforced concrete is a combination of steel and concrete.

Concrete in its qualities of strength is very similar to stone. It will stand great pressure, or **compression,** but is comparatively weak in resisting pull, or **tension.**

Because concrete is strong in compression, and steel is strong in tension, steel rods are embedded in the concrete and take the tension, and the concrete takes the compression. This is the basis of reinforced concrete. In this way each material does the work best suited for it.

Beams and Girders

The principle of reinforced concrete is clearly shown in the case of a beam. If a beam is laid on two supports and a heavy load is placed on the center, the top of the beam is in compression while the bottom is in tension. If the beam were of wood, it would be very noticeable, as the wood in the top of the beam would be crumbled together, while at the bottom of the beam it would be torn apart. (Fig. 34.)

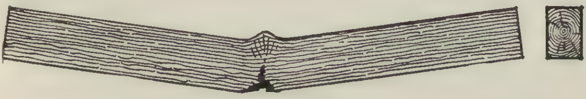


Fig. 34.

The same action occurs in a concrete beam. Figure 35 shows a concrete beam broken in two by a load on the center. The point where the break first occurs is at the bottom because the concrete is weak in tension. If there had been some steel bars, which are very strong in ten-

sion, in the bottom of the beam as shown in Figure 36 the steel would have taken the tension.

Fig. 35.

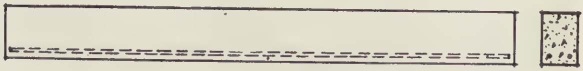


Fig. 36.

Concrete is fireproof and is not harmed by water; while steel loses its strength when heated and rusts if subjected to moisture. When embedded in concrete, the steel reinforcing rods are protected from fire and water. In all reinforced concrete work, the steel rods should be covered with from one to two inches of concrete.

When a plain concrete beam is loaded until it begins to break, it cracks in several places, as shown in Figure 37. In the center of the beam the cracks are perpendicular, while toward the ends the cracks are more and more at an angle. It is readily seen that the proper place for the reinforcing steel is at right angles to the cracks; but in practice this is impossible, as it would require such complicated placing of the steel. A compromise is therefore made.

Fig. 37.

Location of Reinforcing Steel

Some of the bars are left straight for the entire length of the beam. These are at right angles to the cracks near the center, as shown in Figure 38. Then some of the bars are bent, as shown in Figure 39. These, known as double-bent bars, take care of the possible cracks toward the ends. Smaller-sized bars, in the shape of a "U", and known as stirrups placed closer together near the ends of the beams

than toward the center, are used to take care of additional stresses, Figure 40.

Thus, in Figures 38, 39, and 40 are shown the three types of bars for beam reinforcing; and in Figure 41 the complete reinforcing.

Fig. 38.

Fig. 39.

Fig. 40.

Fig. 41.

Kinds of Beams.

Beams are called simple if they extend between two supports only, neither end being fixed. Beams in large building work are usually made to extend from one side of the building to the other, being supported by a number of intermediate columns. These are known as continuous beams.

Another type of beam is the cantilever, in which only one end of the beam is supported. This end must be securely held, as if in a vise. This type is seldom used, however.

Loads

The loading on a beam may be uniformly distributed throughout the entire length, or concentrated in one point; or a combination of both. A beam supporting a

wall of uniform weight and thickness, is an example of a uniformly loaded beam, Figure 42.

Fig. 42.—Uniformly Loaded Beam.

If, instead of this wall, the beam carries the load transmitted from another beam, there would be a concentrated load, Figure 43. If the beam carries both the wall and the load from another beam, there would be a combination loading, Figure 44.

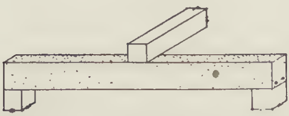


Fig. 43. — Concentrated Load on Beam.

The superimposed load, or the load that the beam carries, is called the **live** load.

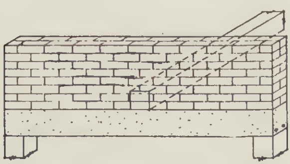


Fig. 44.—Combination of Uniform and Concentrated Loads.

The weight of the beam itself is called the **dead** load. The dead as well as the live load must always be taken into consideration in design. A beam must be designed sufficiently strong to transmit its load to its supports.

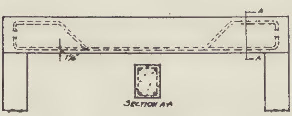


Fig. 45.—Beam Reinforcing.

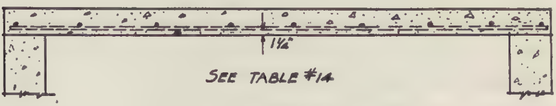


Fig. 46.—Slab Reinforcing.

TABLE 13

Total Safe Live Loads in Pounds Uniformly Distributed, for Simple Beams. (See Figure 45.)

Depth in Inches.	SPAN IN FEET 5	6	7	8	9	10	Depth to Steel.	Depth below Steel.	Steel Area *
For Beams 6 Inches Wide.									
8	2760	2160	1764	1440	1188	960	7.00	1.00	.258
9	3390	2736	2226	1824	1512	1260	7.75	1.25	.282
10	4380	3528	2900	2400	2000	1680	8.75	1.25	.318
11	5490	4428	3654	3072	2592	2220	9.75	1.25	.354
12	6720	5472	4536	3840	3240	2760	10.75	1.50	.396
For Beams 8 Inches Wide.									
8	3680	2880	2352	1920	1584	1280	7.00	1.00	.344
9	4520	3648	2968	2432	2016	1680	7.75	1.25	.376
10	5840	4704	3867	3200	2667	2240	8.75	1.25	.424
11	7320	5904	4872	4096	3456	2960	9.75	1.25	.472
12	8960	7296	6048	5120	4320	3680	10.75	1.50	.528
For Beams 10 Inches Wide.									
10	7300	5880	4760	4000	3330	2800	8.75	1.25	.530
11	9150	7380	6090	5120	4320	3700	9.75	1.25	.590
12	11200	9120	7560	6400	5400	4600	10.75	1.50	.660
13	13000	10440	8680	7360	6300	5400	11.50	1.50	.700
14	15300	12480	10430	8800	7560	6500	12.50	1.50	.760

*See Table 16 for size of rods

Based on information contained in "Concrete Plain and Reinforced" by Taylor and Thompson.

Unit stress for concrete considered as 500 pounds per square inch; for steel as 14,000 pounds per square inch, extra conservative design.

Floor Slabs

The floor slab, between the beams, is considered as a series of little beams laid side by side although of course, the concrete is all poured at one time. The reinforcing is, therefore, very much the same as for beams.

Slabs have also another kind of reinforcing running at right angles to the main reinforcing, known as temperature or distribution reinforcing. Due to change in temperature, concrete expands and contracts, and floor slabs particularly would have a tendency to crack on this account. The temperature reinforcing prevents this. See Figure 46.

When an opening in the floor slab is required for a stairway or other reason, be sure that the reinforcing is **not**

put as shown in Figure 47. It should be placed as shown in Figure 48.

TABLE 14

Total Safe Live Load in Pounds per Square Foot Uniformly Distributed for Simple Slabs. (See Figure 46.)

Depth in Inches.	Span in Feet					Depth to Steel	Depth Below Steel	Steel Area* in Sec. of Slab 1 Ft. Wide.
	4	5	6	7	8			
4	355	210	130	80	51	3¼	¾	0.242
5	551	331	212	137	90	4	1	0.298
6	934	541	352	238	163	5	1	0.372
7	1293	800	527	362	256	6	1	0.446
8	1778	1107	737	513	368	7	1	0.521

*See Table 16 for size of rods.

Based on information contained in "Concrete Plain and Reinforced", by Taylor and Thompson.

Unit stress for concrete considered as 500 pounds per square inch; for steel as 14,000 pounds per square inch, extra conservative design.

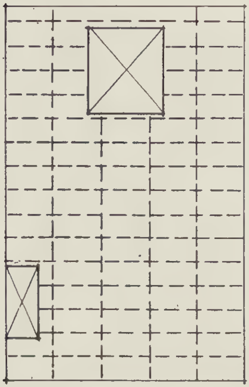


Fig. 47.—Wrong Method.

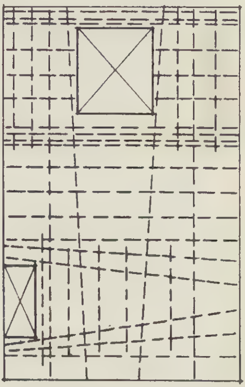


Fig. 48.—Right Method.

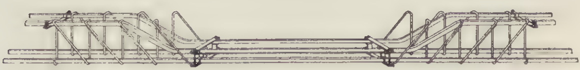


Fig. 49—Assembled Beam Reinforcement

CONCRETE COLUMNS

The loads from the beams and girders are carried to the columns which must be designed accordingly.

Concrete columns of slender proportions should be avoided—the length should not exceed fifteen times the diameter.

Short columns or piers may be built without reinforcement but good practice requires it for safety in construction and to guard against possible eccentric loading. In case of such loading, the column would have a beam action with one side in tension. Reinforcement should, therefore, always be placed within two inches of the surface—not at the center.

Reinforcement may consist of:

(1) vertical, or longitudinal rods; or
(2) bands, hoops or spirals; or
(3) a combination of these.

Longitudinal reinforcement is held in place by means of bands or ties placed at frequent intervals; ¼ inch wire hoops placed on 12 inch centers horizontally is common practice. The amount of longitudinal reinforcement usually runs from 2% to 4% of the column area.

In the case of circular reinforcement, the hoops, bands, or spirals should not be less than 1% of the volume of concrete enclosed.

STEEL FOR REINFORCEMENT

Steel for reinforcement consists of round or square bars or different kinds of wire mesh.

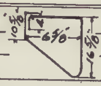
Bars can be bought from the manufacturers direct or from dealers. The price is based on so much per cwt. for bars ¾ inches or over, with an increase in price for the smaller sized bars. In many cases if the builder so wishes, he can submit to the dealer the plans of the structure and buy from him the bars and stirrups properly bent. A type of this is shown in Figure 49.

The first step is to make a list of the steel needed. This

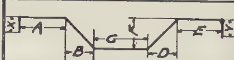
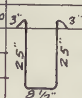
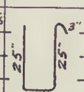
TABLE 15

STEEL BENDING SHEET

COLUMN STEEL

COL. NO.	NO. REQ'D	VERTICAL STEEL				HOOPS				
		LENGTH	SIZE	NO. BARS EACH COL.	TOTAL NO. BARS	SIZE	L'GTH	DIMENSIONS	NO. EACH COL.	TOTAL REQ'D
C-1	4	18'-1"	5/8" φ	6	24	1/4" φ	49 1/2"		30	120
C-2	10	18'-1"	5/8" φ	6	60	1/4" φ	76 1/2"		15	150

GIRDER STEEL

GIRDER NUMBER	TOTAL NO. OF GIRDERS	STRAIGHT BARS				DOUBLE BEND BARS												STIRRUPS				
																						
		NO.	SIZE	LENGTH	TOTAL	NO.	SIZE	L'GTH	A	B	C	D	E	F	X	Y	TOTAL NO.	SIZE	LENGTH	NUMBER	DIMENSIONS	TOTAL NO.
G-1	4	4	1" φ	26'-8"	16	4	1" φ	28'-8"	8'-6"	2'-0"	5'-6"	2'-0"	8'-6"	2'-0"	–	–	16	1/2" φ	61 1/2"	26		104
G-2	8	4	1 1/8" φ	32'-6"	32	4	1 1/8" φ	33'-6"	11'-9"	2'-0"	6'-0"	2'-0"	11'-9"	2'-0"	–	–	32	1/2" φ	64 1/2"	30		240
G-3	4	4	1" φ	32'-6"	16	4	7/8" φ	33'-6"	11'-9"	2'-0"	6'-0"	2'-0"	11'-9"	2'-0"	–	–	16	1/2" φ	61 1/2"	26		104

list should show the location, size, length and dimension of the bars required. The bars larger than ¼ inch or perhaps ⅜ inch are usually ordered to the exact length required so that no cutting of these bars on the job will be required. A typical list of the steel for a beam and girder floor is shown in Table 15.

Fig. 50.—Rack for Storing Steel.

Before the steel is received on the job, racks should be built in order that it can be stored for proper checking; so that the proper length bar can be found as needed. Such a rack is shown in Figures 50 and 52. As the steel is received it should be measured and placed in the proper

Fig. 51.—Measuring Stick for Steel Bars.

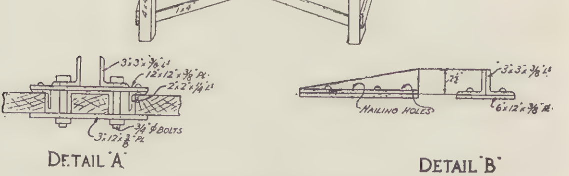
position in the rack. A simple way to do the measuring is to take a long, smooth board and nail a stop block at one end and on it mark a scale in chalk as in Figure 51.

Fig. 52.—Storing Steel.

BENDING STEEL

Reinforcing bars up to 1 inch size can be bent cold by hand. Above this size it will be necessary to heat the bars before bending, but the heat should never be more than a dull red.

The most simple device for bending bars is a bending table as shown in Figure 53. This consists of a heavy



BAR BENDING TABLE

Fig. 53.—Bar Bending Table.

table with the legs preferably sunk into the ground to secure rigidity. The two plates "A" are adjusted to the proper position by means of bolts and the two plates "B" are spiked to the table in the proper position. The bending is done by means of slipping a long heavy pipe over the end of the rod to secure the necessary leverage. When the blocks are set for a certain size of bend all bars in the building of these dimensions should be bent and the location of the bars painted on the end. The bending table in use is shown in Figure 54.

Fig. 54.—Bending Table.

Fig. 55.—Bending Stirrups.

The next step will be the bending of hoops for column reinforcing and stirrups for beams and girders. This material is usually ¼ inch and is easily bent. The bars are first cut to the right length and the bends made by slipping a small pipe over the bar and bending in a small block as shown in Figures 55 and 57. Usually two may be bent at once.

For cutting bars up to ¾ inch a small cutter such as is shown in Figure 56 can be used. The larger bars will have to be cut with a hack saw.

Fig. 56.—Cutting Small Bars.

BENDING CIRCULAR STEEL

For silos, grain elevators and circular tanks it is necessary to bend the reinforcing steel in the form of hoops. In large diameter structures it is sufficient to bend the horizontal curved bars against the vertical steel. For small structures it will be necessary to bend it accurately to shape. Perhaps the most successful method is the one shown in Figure 58. The radius of the block should be

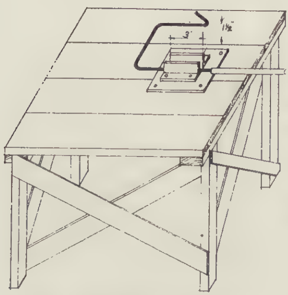


Fig. 57.—Stirrup and Hoop Bending Table.

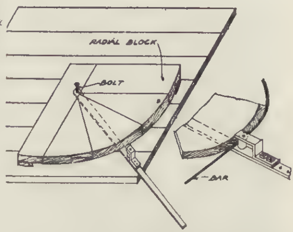


Fig. 58—Bar Bender for Making Horizontal Hoop Reinforcing for Tanks, Bins, etc.

less than half of the diameter of the hoops to allow for the spring in the steel. It is not necessary that it be absolutely accurate, as the hoops can be sprung slightly without destroying the circular shape. The ends of the hoops should be securely tied together and the best method is by a wire cable clip as shown in Figure 59.

Fig. 59.—Clip for Fastening Reinforcement Together.

PLACING STEEL

Column reinforcing is assembled previous to placing it in the column forms, that is, the hoops are wired to the vertical rods and the reinforcement thus completely

assembled is placed in the form. The most convenient method of assembling is shown in Figure 60.

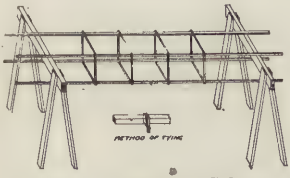


Fig. 60.—Assembling Column Reinforcing.

Spiral reinforcing comes in the shape of coils, the coils being of any diameter required. Before placing in the column form the spirals must be attached to spacing bars of which there are usually three. It is usually better to order them attached to two spacers and shipped knocked down as in Figure 61. When received on the job the spirals are opened up and the third spacing bar attached.

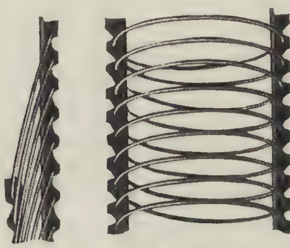


Fig. 61.—Collapsible Spiral Column Reinforcing.

In placing beam and girder reinforcing it is usually best to place stirrups and bars separately, the stirrups, of course, first. The stirrups are made with the two wings so that they will occupy their correct place in the beam with the bottom part about 1¼ inches from the bottom of the form. The larger bars rest on these stirrups thus giving the required 1½ inch of concrete below the rods for fireproofing as shown in Figure 62. In some cases the stirrups may not give the necessary support to the bars at the bottom and this can be taken care of by making small concrete blocks 1½ inches thick and placed in the bottom of the beam forms to support the bars.

In placing the slab steel in beam and girder construction it is necessary to have some means of support to keep the slab bars near the top. This can be done as

shown in Figure 64, by the use of special cast iron chairs spanning the opening of the beam form, and supporting a small "T" bar. These chairs can be purchased from dealers in reinforcing specialties or a concrete block supporting a bar as shown in Figure 63 can be used. This cut also shows the method of keeping the slab steel in the proper position by stapling it down to the forms, the staples being placed over the temperature reinforcing.

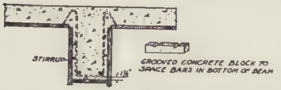


Fig. 62.—

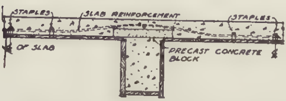


Fig. 63.—Concrete Block Support for Slab Steel Over Beams.

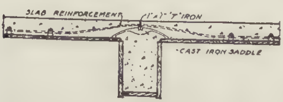


Fig. 64.—Cast Iron Chair Support for Slab Over Beam.

In placing flat slab steel it is necessary to support the steel over the column heads, at the approved height. This can be done by bending a bar in the form of a square and supporting it on pre-cast concrete blocks. The slab steel is then placed in the proper position and the necessary bends made by the use of a "hickey" as shown in Figure 65.

A "hicky" is a "T" shaped contrivance the upright portion made out of a ¾ inch round bar to which is welded a flat piece about 3 inches wide and ½ inch thick. The length of the cross piece is governed by the length of the

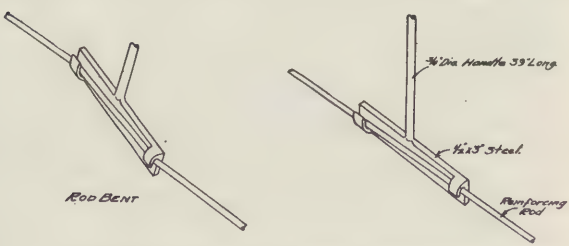


Fig. 65.—"Hickey" for Bending Flat Slab Steel.

bend to be made. At diagonally opposite corners of the flat part are heavy hooks made by welding on small pieces.

To make a bend the hickey is hooked over a bar as shown in Figure 65 and the bar held in place with the foot. A sharp swing on the handle, and the bar is bent as shown in the lower part of the figure.

Steel placed as reinforcement must be free from oil or paint or scaly rust. In this connection the forms should be oiled before the steel is placed. The ordinary bright red rust is in no way objectionable and probably increases the bond between the steel and concrete.

TABLE 16

Areas and Weights of Round and Square Bars.

Thickness or Diameter (Inches.)	SQUARE BARS		ROUND BARS	
	Cross Section Area (Inches.)	Weight, Pounds, Per Foot.	Cross Section Area (Inches)	Weight, Pounds. Per Foot.
1/16	.0039	.013	.0031	.010
1/8	.0156	.053	.0123	.042
3/16	.0352	.120	.0276	.094
1/4	.0625	.212	.0491	.167
5/16	.0977	.332	.0767	.261
3/8	.1406	.478	.1104	.376
7/16	.1914	.651	.1503	.511
1/2	.2500	.850	.1963	.668
9/16	.3164	1.076	.2485	.845
5/8	.3906	1.328	.3068	1.043
11/16	.4727	1.607	.3712	1.262
3/4	.5625	1.913	.4418	1.502
1	1.0000	3.400	.7854	2.670
1 1/4	1.5625	5.313	1.2272	4.172
1 1/2	2.2500	7.650	1.7671	6.008
1 3/4	3.0625	10.410	2.4053	8.178
2	4.0000	13.600	3.1416	10.680

Joints in reinforcing steel are made by lapping the bars side by side a distance of 40 diameters—20 inches for ½ inch round rods.

For columns reinforcing bars project 40 diameters above the floor length to form the bond between the columns at each floor.

The steel must be accurately placed as called for in the plans; otherwise the concrete will not have the strength

for which it was designed. Care must be taken, therefore, that the reinforcing steel is tied together so that it will not be displaced during the pouring of the concrete. This tying is done with No. 14 or No. 16 soft annealed iron wire. There are also many clip devices on the market for tying the intersections.

CHAPTER III. FORMS FOR CONCRETE

Forms must be watertight, rigid and strong enough to sustain the weight of the concrete. They must also be simple and economical and if to be used again, designed so that they may be easily removed and re-erected without damage to themselves or to the concrete. The different shapes into which concrete is formed mean that each job will present some new problems to be solved, but there are typical forms that will cover a large part of concrete construction.

Most forms at the present time are made of wood, although steel forms are often used for work with large, flat surfaces, particularly sidewalks, curbs, roads and retaining walls and columns where the forms are to be used repeatedly. It always must be borne in mind that ease in removal and erection are the largest factors in economical design of forms and each job should be thoroughly studied and forms designed with this point in view.

Fig. 66.—Jenny Winch used for Hoisting Steel or Forms.

Lumber for Forms

Lumber for forms will vary with the locality. The ideal combination is strength and lightness. White pine, spruce and the softer southern pines are the best. All lumber should be dressed at least on one side and both edges, and in most cases it will be cheaper to have it dressed on both sides. Since most forms are cleated, dressing is necessary in order that the face next to the concrete will be uniform. In footings and rough work that is not to show, practically any lumber can be used that will hold wet concrete. But for forms that are to be used again, the additional ease of cleaning will pay the cost of having the lumber dressed.

The edges may be cut square, mitred or tongued and grooved. The last method makes a more water-tight joint and tends to prevent warping. The mitred joint is used for lumber that has a tendency to swell so that the thin edge will crush against the next piece and give a tight joint.

It is seldom economical to rework second-hand lumber for forms. Old lumber must be pulled apart and nails drawn, after which it must be carefully cleaned. Even then it will usually have so much concrete adhering that it will dull tools very rapidly. It costs about twice as much to construct forms of old lumber. New lumber will be found cheaper in the end.

The thickness of the lumber varies according to its use. For short spans between supports, such as floor slabs and wall forms, 1 inch stock is commonly used; for columns either 1 inch or 1¼ inch, according to the spacing of the yokes; for beam sides and bottoms 2 inch. Heavier material is used for beams, as they must be strong and rigid to withstand the handling they receive when moved from floor to floor and to hold the weight of concrete between supports without deflection. In ordinary dressed lumber it is customary to give the sizes of the rough lumber from which it is worked up, and in the figures in this series

sizes have been so noted. Thus 2″ D. 4 S. means 2-inch lumber dressed 4 sides; i. e., both sides and edges. This dressing cuts down the 2-inch thickness to about 1⅞ inches.

Removal of Forms

Any rules for removal of forms must be approximate and must be used in conjunction with experience and judgment, but those given below by Taylor and Thompson, in their book "Concrete Costs", will serve as a guide:

"Walls in mass work: One to three days, or until the concrete wall will bear pressure of the thumb without indentation."

"Thin walls: In summer, two days; in cold weather, five days".

"Columns: In summer, two days, in cold weather, four days, provided the girders are shored to prevent any appreciable weight reaching the columns."

"Slabs up to seven foot spans: In summer, six days; in cold weather, two weeks.

"Beam and girder sides: In summer, six days; in cold weather, two weeks.

"Beam and girder bottoms and long span slabs: In summer, ten days or two weeks; in cold weather, three weeks to one month."

These times as given are conservative. Column and wall forms are often stripped within twenty-four hours, and girders and floor slabs in three days, but all floor work must be properly shored for at least twenty-eight days, as it must not only support its own weight but that of the construction above it.

If properly constructed and ordinary care taken in stripping and handling, forms may be used ten or twelve times in building construction. This will cover practically any structure. If they are to be used more often than this, the forms must be especially well made and more than ordinary care used in stripping. In this way they may be used as many as fifteen times.

Clearance

Forms must be designed so that they can be easily removed. There always will be slight movements of the forms due to the weight of the concrete. It is, therefore, necessary to give particular care to the joints made by the different units of the forms and allow sufficient clearance for any movement of the forms. This is well illustrated in the joint where a floor panel rests on a beam side. The panel should have a beveled edge and only project about half way onto the beam side. If the edge of the panel is made flush with the inside face of the beam before the form is filled, it will be found to be projecting into the concrete of the beam when the time comes to strip it, due to the sides of the beam spreading slightly from the weight of the concrete. Figure 67 shows the right and wrong ways to make such connection.

The upper figures show the forms before filling and the lower figures the position the beam sides take due to the pressure of the concrete.

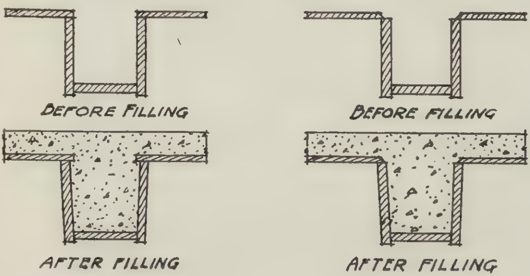


Fig. 67.—

Wrong Method. Right Method.

Foundation and Wall Forms

The construction of foundation and wall forms is clearly shown in Figures 68-73.

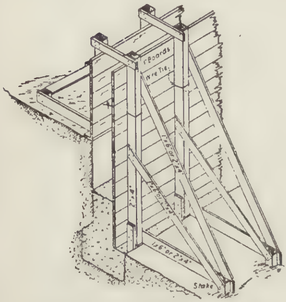


Fig. 68.—Forms for foundation walls built in solid earth.

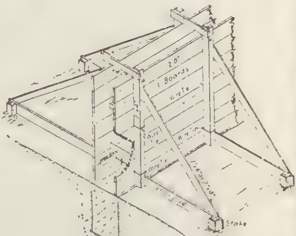


Fig. 69.—Form for wall above foundation.

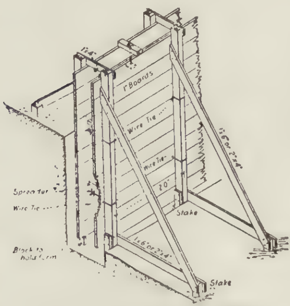


Fig. 70.—Forms for wall in soft earth.

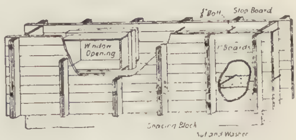


Fig. 71.—Arrangement of form when window is to be inserted—Sectional form to be raised as wall is built up and used over and over.

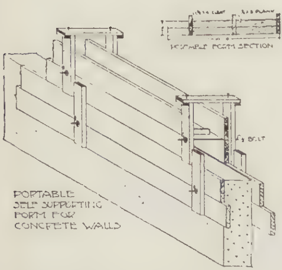


Fig 72.—Form for carrying wall up with use of least possible lumber.

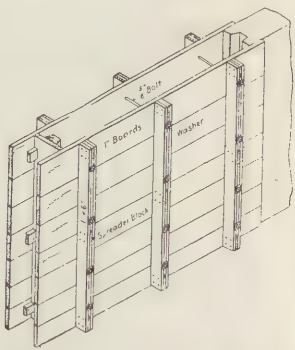


Fig. 73. — Form for continuing wall lengthwise with notch in completed part to make a bond with newly deposited concrete.

Column Forms

Square and octagonal column forms are generally made of wood, while round column forms are usually of steel. Columns decrease in size from the lower to the upper stories and the forms must be designed so that they can be easily reduced to allow for this.

All square columns should have the edges beveled as it is difficult to get a perfectly sharp corner, and sharp corners are easily knocked off. When an especially good appearance is desired, the corners are rounded as shown in Figure 74—"E."

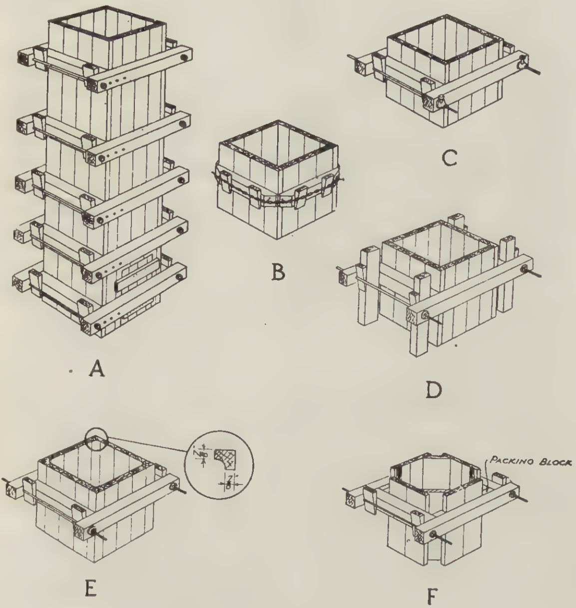


Fig. 74.—Column Forms.

When the forms are cleaned before concreting, the rubbish will be swept into the columns, and clean-out holes

should be left in the bottom of the column forms and should be of ample size to allow thorough cleaning. The pieces of board removed for the clean-out hole should be nailed to the form so that it will be ready to put back in place. In some cases it will be found easier to erect the column with three sides fastened together leaving the fourth out until the reinforcement is placed. This is usually necessary when column reinforcing is more than one story high, or when the reinforcing projects very far above the floor. Otherwise, it is preferable to assemble the column form complete and lift it into place. Exterior columns are usually built in place, one side at a time on account of the danger of the form getting away from the workmen and falling off the building.

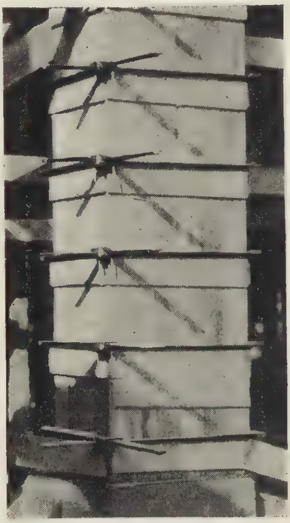


Fig. 75.—A Convenient Form Clamp.

There are several types of square column forms which have become practically standardized in building construction. The most common is that shown in Figure 74. The sheathing is $1\frac{1}{4}$-inch T. & G. D 2 S, and yokes are 4-inch x 4 inch yellow pine. The bolts should be at least $\frac{5}{8}$ inch, as smaller stock will be bent too easily by the wedges, and frequent straightening will be required.

In this column form two of the sides are made with the yokes flush with the edge of the sheathing. The other two sides have the yokes projecting at least eight inches beyond the sheathing, giving room for the driving of a wedge between the bolt and the yoke. The reduction in the size of this column is by taking off a strip along one edge of the

sides which do not have the yokes projecting and by taking a strip off one of the boards on the sides having projecting yokes. Then new bolt holes are either bored in the yokes, or packing strips are placed on the yokes for the wedges to bear against. If there is a boring machine on the job, the yokes should have a series of holes bored in them before they are fastened to the column sides so that it will not be necessary for the carpenters to bore them by hand.

Forms for octagonal columns are made as shown in Figure 74—"F." This column is identical with the one shown in A except that pieces are inserted in the corners to give the column eight sides. The flare is made at the top of the column by fitting in triangular pieces of wood.

Since fresh concrete is practically liquid and over twice as heavy as water, the column form must be designed to withstand the bursting pressure of the concrete. This will make it necessary to have the yokes closer together at the bottom than at the top.

In place of bolts, rods with a malleable iron clamp fastened in place with a set screw are often used for form work. These clamps may be obtained from supply houses. The clamp is slipped over the rod and brought to a firm bearing by a device furnished by the makers of the clamps. Then the set screw in the clamp is tightened, holding the clamp in place.

In the same figure is shown a method of clamping columns by using a chain. The chain is hooked around the column as tight as possible and the slack taken up with wedges.

Table 17 gives spacing of yokes for various sizes and heights of columns.

When column forms are very wide, larger yokes must be used or bolts placed through the center of the column.

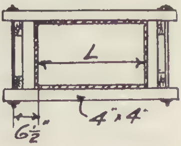
Exterior column forms require different treatment as one side must project over the edge of the building. Such a column is illustrated in Figure 76 and 77. The two bolts shown at the top of the form are left in the concrete with

TABLE 17

Spacing of yokes for columns.

How to use Table: To find spacing of yokes for a 24″ x 18″ column 10 feet high, use column headed 24″. Read up column from 10′ line and the spacing of yokes will be found—14″ for bottom yoke, 16″ for next upper yoke, 22″ for next, and so on to top.

	LARGEST DIMENSION OF COLUMN IN INCHES							
HEIGHT	16″	18″	20″	24″	28″	30″	32″	36″
1′			27″	23″		20″	19″	17″
2′	31″	29″			21″			17″
3′			26″	23″	21″	20″	19″	
4′	31″	28″				19″	18″	17″
5′					20″			15″
6′		28″	26″	23″	18″	18″	17″	12″
7′	30″			22″		18″	13″	11″
8′			24″		15″	12″	12″	10″
9′	29″	26″		16″	13″	12″	10″	8″
10′		20″	19″	14″	12″	10″	10″	8″
11′			16″	13″	10″	9″	8″	7″
12′	21″	18″	15″	12″	9″	8″	8″	6″
13′	20″	16″	14″	11″	9″	8″	7″	6″
14′	18″			10″	8″	7″	7″	
15′		15″	12″	9″	8″	7″	6″	
16′	15″	13″	11″	9″	7″	6″		
17′	14″	12″	11″	8″				
18′	13″	12″	10″	8″				
19′	13″	11″	10″					
20′	12″	11″	9″					
	12″							



the ends projecting. To these bolts are fastened blocks to support the overhanging sides of the form. The bolts are removed later by turning out with a wrench. Stud bolts are put in the floor, when it is soft, to which blocks are attached for bracing the form. The blocks may be slotted to allow for adjustment. The brace is nailed directly to the block. In these forms the outside piece is erected first and braced and the other side placed afterwards.

Fig. 76—Outside Column Form.

Round columns are usually built with steel forms and heads. These forms are usually hired for the life of a job and the erection and stripping done by the company supplying the forms. They are used mainly in flat slab construction. The shell is of sheet iron held with clamps and the head is made in sections to allow for reduction.

Forms for Beam and Girder Floor Systems

Forms for beams and girder floors vary somewhat. This variation depends upon whether the beam and girder forms are to be stripped in one piece or the sides are to be removed and the bottoms left in place until the shores are removed.

Removable Beam Forms

If beam forms are to be removed as one piece, they must be strong enough structurally to stand stripping, hoisting,

and re-erection. In such cases the material is usually 2-inch lumber. If the bottoms are left in place, the sides can be made of lighter material.

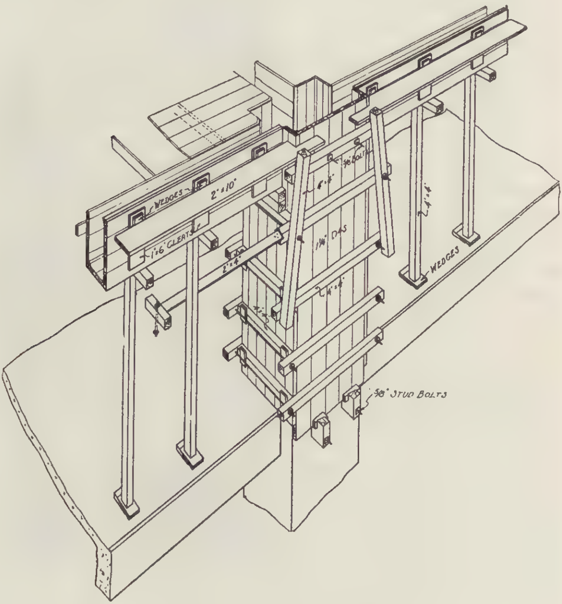


Fig. 77.—Beam and Girder Construction.

Column forms must be designed to withstand the bursting pressure of wet concrete but beam forms are subjected to little bursting pressure, and mainly must possess strength and rigidity. Forms for most lengths and sizes of beams will vary little in design, since strength and rigidity will be taken care of by the number of supporting posts.

Figure 78 shows the construction of beam forms, girder forms and floor slab panel forms that are to be stripped and handled as a unit. The material for the beams and

girders is 2-inch stock dressed four sides. It should be as wide as possible, making the bottom in one piece to avoid the necessity of cleats across the bottom, which are objectionable in handling due to their catching on obstructions. The beam bottom should be the width of the beam and the sides should lap over the bottom.

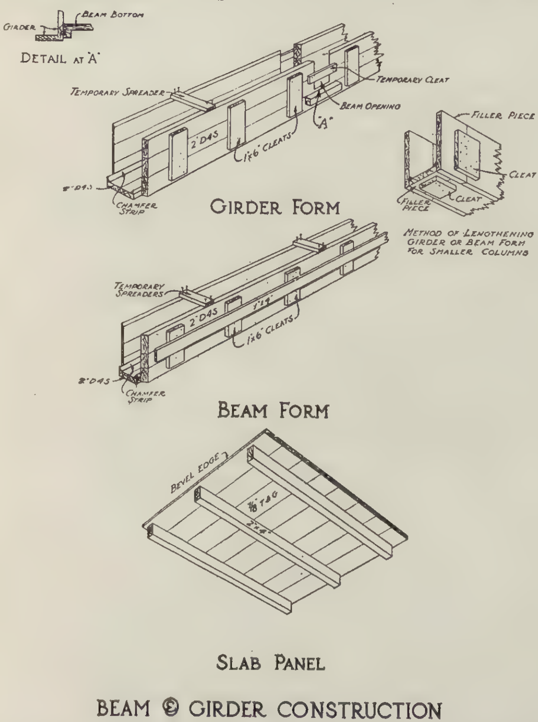


Fig. 78.—Beam and girder construction—Slab, beam and girder forms—for use when the forms are removed entirely as a unit.

The side cleats are of 1-inch by 6-inch material, spaced about 3 feet apart. The sides are fastened to the bottom by nailing. Along the cleats is nailed a piece of 1-inch by

4-inch to support the spreaders of the floor panels. The cross pieces shown on top are tacked on when the form is being handled to prevent the sides from caving in.

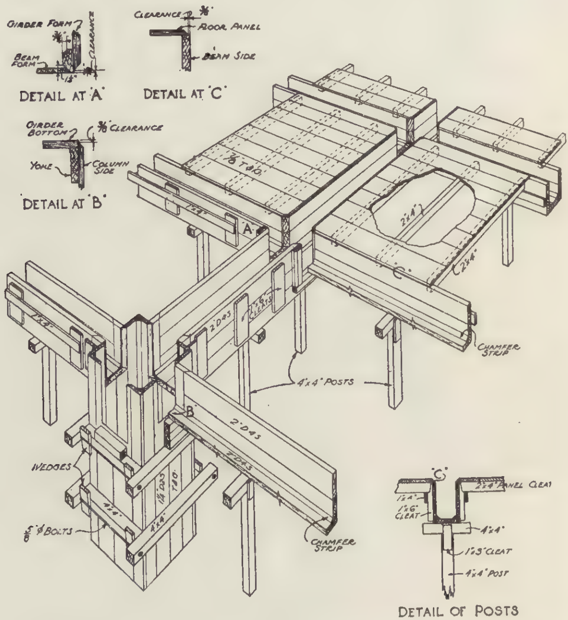


Fig. 79.—Beam and girder construction—View of assembled forms which are to be completely removed as a unit.

Girder forms are the same as beam forms except that the sides are notched to receive the beam forms. More care must be taken in handling them, as they are weaker, due to these cuts. Temporary cleats always should be nailed across the beam opening while they are being handled.

Exterior beams and girder forms require special attention on account of the difficulty of bracing the exterior side. One method of doing this was shown in Fig. 76.

Slab panels are usually made of $\frac{7}{8}$-inch material, tongued and grooved. These are cleated together with 2 x 4's, which also serve as spreaders.

Fig. 79 shows the assembling of the forms shown in Fig. 78. The beam and girder forms rest on blocks on the top yokes of the columns. The ends of the beam and girder bottoms are flush with the column forms. The end of the sides of the girder or beam forms is made of a piece that is loose, so that it can be easily removed to facilitate stripping. As the columns grow smaller this loose piece is employed to lengthen out the beam and girder forms as shown in Fig. 78; in the detail figure in the upper right-hand corner.

The connection of the beam and girder is shown in Fig. 79, point "A". The beam bottom is flush with the exterior of the girder side and rests on a cleat nailed on the girder side. The beam sides are beveled to receive a piece of 2 x 4 chamfered on two edges. Note the detail "B" which shows the bottom connection.

Particular attention is called to the details, "A," "B" and "C," which show the clearances necessary for the proper stripping of the forms. These clearances allow for the slight movement of the forms which it is impossible to prevent, due to the weight of the concrete.

Stripping Order

of beam and girder forms which are removed as a unit:

(1) Remove column wedges.

(2) Remove column bolts.

(3) Remove blocking under the ends of beams and girders, including cleats under beam forms at connection with girder.

(4) Remove key pieces at connections of beams and girders to columns and beams to girders.

(5) Remove column sides. The removal of the key pieces allows sufficient room for the upper end of the column to slide by the beam or girder until it is free.

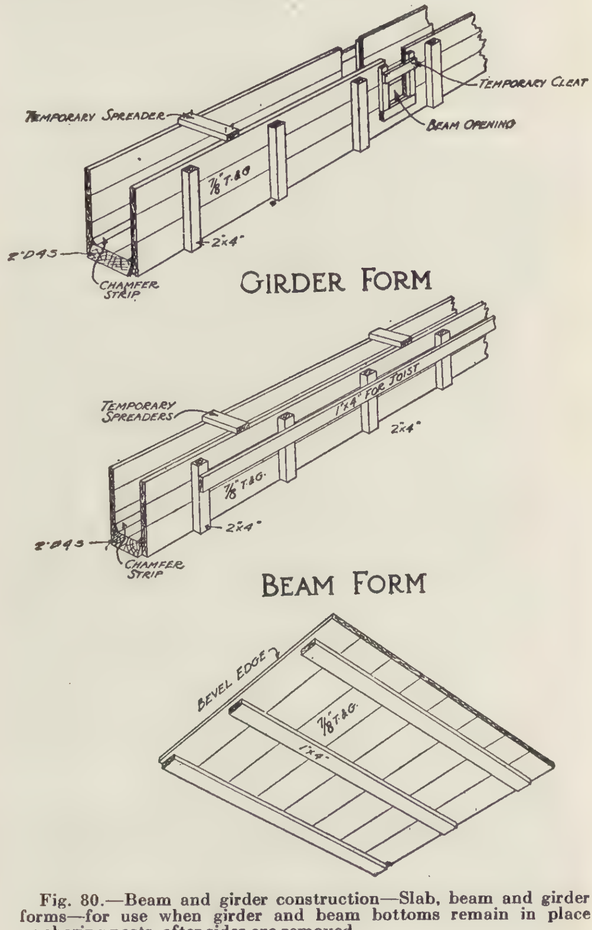


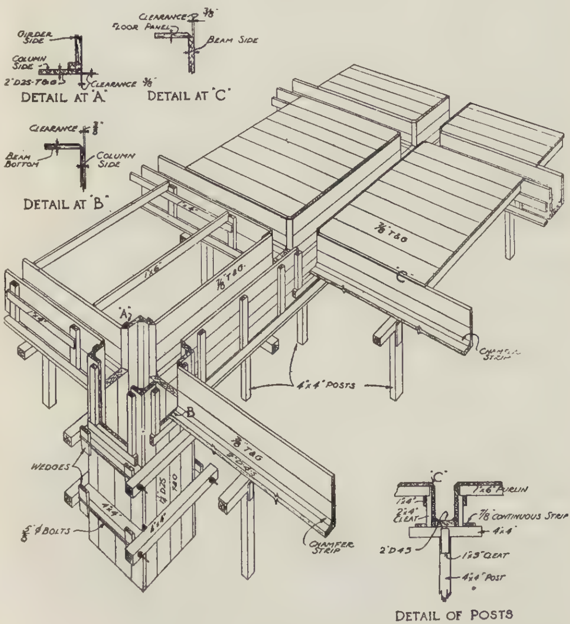
Fig. 80.—Beam and girder construction—Slab, beam and girder forms—for use when girder and beam bottoms remain in place on shoring posts, after sides are removed.

(6) Remove shoring under girders and remove girder forms in one piece. Reshore the beams.

(7) Remove floor panels.

In Figures 80 and 81 are shown a type of form for beam and girder construction that varies from that shown in Figures 78 and 79 in that the beam and girder bottoms are left in place until it is time to remove the shores. Also loose purlins are used to support the floor panels.

Note also that the details of the connections of the beam and girders and columns are different.



DETAILS OF WOOD FORMS

Fig. 81.—Beam and girder construction—View of assembled forms in which the bottoms of beam and girder forms will remain in place after sides are removed.

The beam and girder bottoms are of 2-inch material, dressed four sides, while the sides are of lighter material, such as $\frac{7}{8}$ T & G sheathing.

The beams and girder sides are held tight to the bottom by continuous strips nailed to the heads of the posts.

Stripping Order

of beams and girder forms in which bottoms remain in place after sides are removed:

(1) Remove column wedges.
(2) Remove column bolts.
(3) Remove column sides.
(4) Remove strips holding lower edge of beam and girder sides.
(5) Remove floor panel purlins.
(6) Remove girder sides.
(7) Remove beam sides.
(8) Remove slab panels.
(9) When floor has gained sufficient strength the beam and girder bottoms are removed with the shoring posts.

Flat Slab Forms

Flat slab forms are built on the principle of supporting the entire weight of the concrete on the shoring posts, the columns taking none of the load.

In Fig. 82, the posts are of 4 inch x 4 inch material carrying longitudinal 4 inch x 4 inch stringers. These posts are about 5 feet apart each way. The stringers are fastened to the posts with cleats. The posts are braced in each direction with 1 inch matrial. On top of the stringers are laid 4 inch x 4 inch cross pieces upon which are laid the floor panels. The cross pieces and panels are not nailed to the stringers.

The forms for the depressed heads rest directly on the stringers and their construction is shown in the figure. They are made in two sections for ease in handling. The

column forms are built up either in wood or steel and have no part in supporting the slab forms.

The slab panels are of ⅞ inch T. & G. material made up in sections about 5 feet long and about 2 feet wide.

Fig. 83 shows another method of constructing flat slab forms. The depressed heads are supported on a separate frame work so that it can be easily taken apart and re-erected.

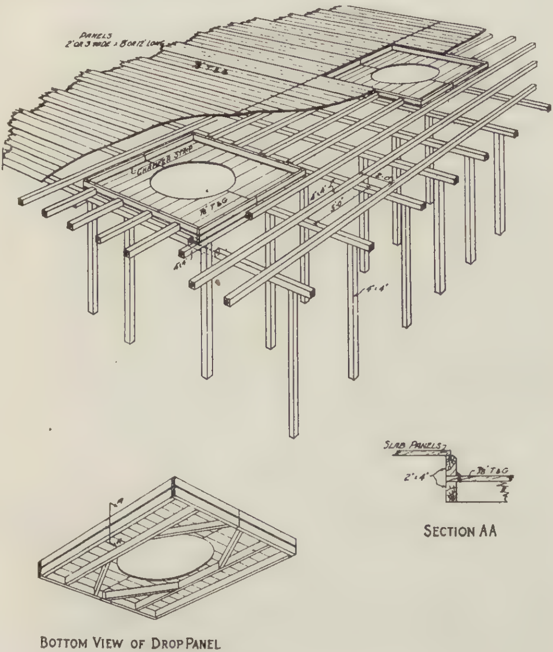


Fig. 82.—Flat slab construction—Forms for flat slab construction: depressed heads resting directly on stringers.

The posts are 4-inch x 4-inch and carry 4-inch x 6-inch stringers. On these stringers are laid 3-inch x 4-inch cross

pieces to hold the floor panels. These panels are made the length between column centers and about one-quarter the width. The side of the depressed head is formed by a piece nailed to the floor panels, allowing more leeway if columns are not exactly centered.

The following tables give the sizes of posts, stringers and joists for flat slab forms:

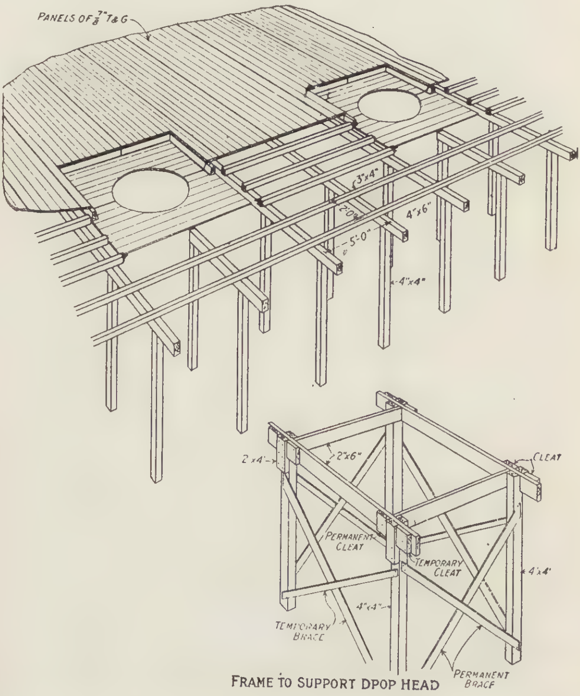


Fig. 83.—Flat slab construction—Alternative forms: depressed heads on separate frame.

TABLE 18
Various Thicknesses of Slabs Referred to in Tables 19, 20, 21, 22 and 23 by Number.

Slab No.	Slab Thickness in Inches of Solid Concrete Slab.	Combination Tile and Concrete Slab.	Slab No.	Slab Thickness in Inches of Solid Concrete Slab.	Combination Tile and Concrete Slab.
1.........	3	....	10.........	7	13
2.........	4	6	11.........	....	14
3.........	....	7	12.........	8	....
4.........	....	8	13.........	....	15
5.........	5	....	14.........	9	....
6.........	....	9	15.........	10	....
7.........	....	10	16.........	11	....
8.........	6	11	17.........	12	....
9.........	....	12	....	....	....

TABLE 19
Posts for Centering

3 x 4-in. solid, to be spaced 4 x 6 ft. or less, under slabs 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 braced in four directions every 7 ft; and to be spaced 4 x 4 ft. or less under slabs 11, 12, 13, 14, 15, 16, 17 and 4 ft. apart under girders or beams.

4 x 4-in. solid ,or T-post of two 2 x 4 in. properly spiked, to be spaced 6 x 6 ft. or less under slabs 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, braced in four directions every 8 ft.; and to be sapced 4 x 6 ft. or less under slabs 11, 12, 13, 14, 15, 16, 17 or 5 ft. apart under girders or beams.

6 x 6-in. solid, or T-post or 2 x 4 in. and 2 x 6 in., properly spiked, braced in four directions every 8 ft. and to be spaced 6 x 6 ft. or less under slabs 12, 13, 14, 15, 16, 17 or 6 ft. apart under girders or beams.

TABLE 20
Size and Spacing of Joists on 4-Foot Spans

Slab No.	Size,	Spacing,	Slab No.	Size,	Spacing,
	Inches.	Inches.		Inches.	Inches.
1.......	2 x 4 2 x 6	16 24	16.........	2 x 6	21
			17.........	2 x 6	21
2 to 15 incl.	2 x 6	24			

TABLE 21
Size and Spacing of Joists on 6-Foot Spans

Slab No.	Size,	Spacing,	Slab No.	Size,	Spacing,
	Inches.	Inches.		Inches.	Inches.
1, 2.....	2 x 6 2 x 8	16 24	7, 8.....	2 x 6 2 x 8	12 24
3.......	2 x 6 2 x 8	15 24	9, 10, 11, 12, 13.	2 x 6 2 x 8	12 21
4, 5, 6...	2 x 6 2 x 8	14 24	14, 15, 16, 17.	2 x 8 2 x 10	21 18

TABLE 22

Minimum Sizes of Girders across Posts on 4-Foot Span, Span of Joists 4 Feet or 6 Feet

Slab No.	Size, Inches.	Slab No.	Size, Inches.
1, 2	2 x 10, 3 x 8 or 4 x 6	15	3 x 10, 4 x 8, 6 x 6
3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13	2 x 10 or 3 x 8	16	3 x 10 or 4 x 8
14	2 x 10, 4 x 8 or 6 x 6	17	2 x 12, 3 x 10 or 4 x 8

TABLE 23

Minimum Sizes of Girders across Posts on 6-Foot Span, Span of Joists 4 Feet or 6 Feet

Slab No.	Size, Inches.	Slab No.	Size, Inches
1	2 x 12 or 3 x 10	11	3 x 12
2, 3	3 x 12, 4 x 10 or 6 x 8	12, 13	3 x 12 or 6 x 9
4, 5, 6, 7, 8, 9	2 x 14, 3 x 12, 4 x 10 or 6 x 8	14	4 x 12 or 6 x 9
10	2 x 14 or 3 x 12	15	3 x 14, 4 x 12, 6 x 9, 8 x 8
		16	2 x 16, 3 x 14, 4 x 12 or 8 x 8
		17	2 x 16, 3 x 14, 4 x 12 or 6 x 10

Wall Forms

Fig. 84 shows the construction of wall forms. These are made up of convenient sized panels of ⅞ inch T. & G. material cleated together. These are tacked on standards made up of two pieces of 1-inch x 4-inch material with one-inch separator blocks. Through the standards and the forms are run ⅝-inch bolts. The forms are kept the proper distance apart by small sticks cut to a length equal to the thickness of the wall. These sticks are knocked out as the concrete is poured. Another method of keeping the forms apart is by using pre-cast cylinders of concrete with a hole for the bolt through the center. These blocks remain in the concrete.

Fig. 84 also shows the method of connecting wall and column forms when they are poured at the same time and also the construction of curtain-wall forms. The small detail shows the forms for the window sills when they are poured after the walls.

Sometimes in order to give stiffness to the forms, horizontal 4 x 4's are placed against the standards shown in the sketch in the lower left hand corner of Figure 84.

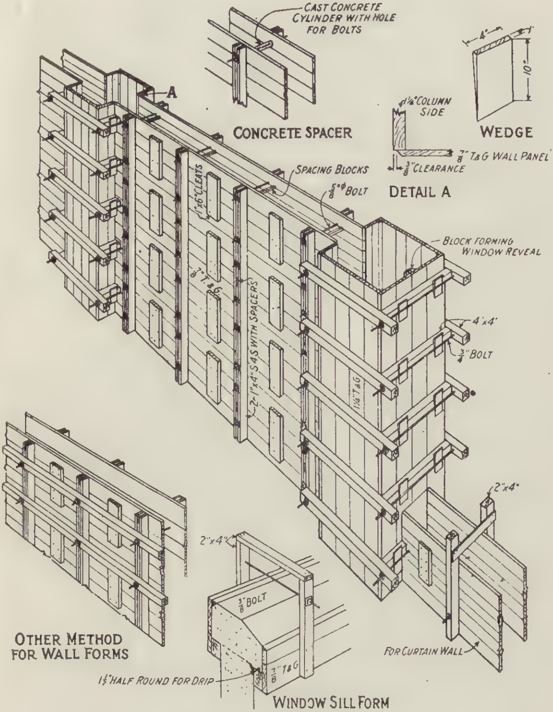


Fig. 84.—Forms for Concrete wall construction.

Forms for Fireproofing of Steel

Forms used in fireproofing of steel with concrete are usually much lighter than those used for structural concrete, since cinder concrete, which weighs far less than stone concrete, is generally employed for fireproofing; because the amount of concrete to be supported is less; and because there is usually no load on the concrete due to building operations.

The forms are usually 1-inch material. Instead of being supported by shores, they are hung from the steel members. This is shown in Fig. 85. Heavy wire is looped under 1 x 4 stringers, the ends of the wire being over the flange of the I-beam. On these stringers rest the beam forms. The purlins for the slab forms rest on "L" shaped members made by nailing two boards together along the edge. The forms are released by cutting the wire under the stringer.

The forms for fireproofing columns are shown in Fig. 85, and usually have 2-inch x 4-inch yokes, or the sides are nailed together at the edges.

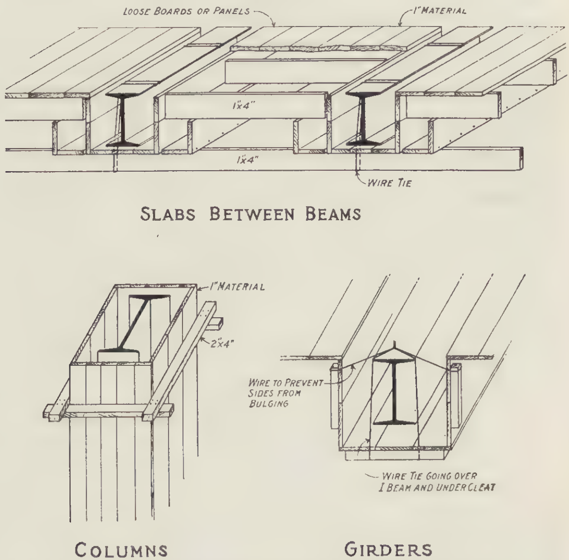


Fig. 85.—Forms for concrete used in fireproofing structural steel members.

Stripping of Forms

Forms must be constructed so that they can be removed without injury to the concrete and, if they are to be used

more than once, without injury to themselves. Particular care has been taken in designing the forms here shown so that the foregoing is possible.

The order in which the stripping of the forms should be done for beam and girder construction is given on page 71. The columns sides are first removed. After removing the blocking between the column yokes and the beam bottoms, and the key pieces between the column sides and beam sides, of the type shown in Fig. 81, the bottom of the column form should be pried loose. After being moved out for 6 or 8 inches, the column side will come free at point "B" and the space occupied by the key piece will give room enough to allow the column side to be removed. In the type shown in Fig. 79, the column sides will slide by the beam forms without the removal of the key pieces.

The next step is to remove the purlins unless they form the panel cleats. This can best be done from a scaffold on horses.

It is then necessary to remove the girder forms. As these are heavy, the best method is shown in Fig. 86. This very simple rig consists of 4 pieces of 4-inch x 4-inch used in pairs. The 4-inch x 4-inch sticks are cut just a little longer than the height between the floor and ceiling slab. Through the upper end, at a point just below the girder forms, are bored holes to take a 1-inch rope. This is knotted against one of the sticks to which is nailed a cleat. The sticks are then erected with the bottoms wedged tight as shown in Fig. 86, and the rope pulled taut and fastened to the cleat. The girder shores are then removed. If the girder form sticks, it can be readily loosened by using goose neck bars as shown in Fig. 86. The girder forms are then dropped on to the ropes and lowered to the floor by releasing the ropes from around the cleats. The girder shores are then replaced.

The same operation is used in stripping the beam and slab forms. The same general method is used in stripping beam and girder forms where the beam and girder bottoms are left in place. In this case, the continuous strip on

top of the posts is first removed and then the beam and girder sides are pried loose, falling on to the ropes.

A similar rig is used for stripping flat slab forms as shown in Fig. 86. The sticks are cut a little longer

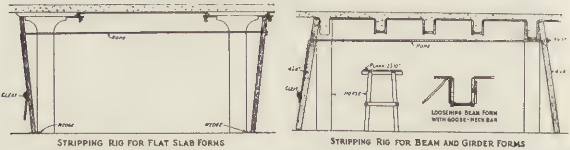


Fig. 86.—Stripping Details—Methods for stripping flat-slab and beam-and-girder forms.

than the story height with the result that any weight on the ropes serves to wedge the sticks together. In stripping the flat slab forms the permanent shores should be placed before the form shores are removed. In order that the panels can be removed when the permanent shores are in place, a small section of the panel is left loose along the joint where the shore is to go. This is shown in Fig. 88. Then the stripping rig is erected and the shores, longitudinal and cross stringers removed and the floor slabs pulled down.

Fig. 87.—Stripping rig in operation.

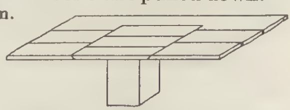


Fig. 88.—Cut-out in panel for slab shore.

In the type of forms shown in Fig. 82, the forms for the depressed heads are removed at the same time as the slab panels, while in Fig. 83, the scaffold holding the depressed head forms is removed first.

The main features of this stripping rig is that **the forms are not injured in stripping** and if, when removing the

shores some beam or slab panel should fall, the workmen will not be injured, as the forms will be caught by the ropes.

Circular Forms

Circular forms are of two types: movable forms, and stationary forms.

In making the movable forms, pieces of lumber are cut and nailed together, as shown in Fig. 89 and then lined with galvanized iron so as to form a smooth, even surface. The forms are generally laid out on a floor, or level piece of ground, by means of a stake at the center and the use of a compass stick with holes at each end, the

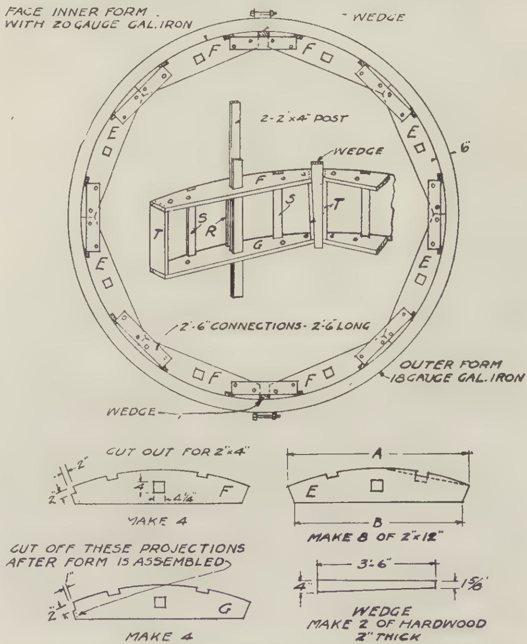


Fig. 89.—Details of circular forms that can be made on the job.

distance between being equal to the radius of the circle. The hole at one end is used for fastening the stick to the stake and the hole at the other end is for a pencil to mark the circle.

In constructing tall tanks or silos, the forms are wedged in place, and filled with concrete. When the concrete is sufficiently hard the wedges are loosened and the forms raised, guided by the uprights and wedged in place and again filled. Movable forms work very advantageously on certain classes of work, such as silos and grain tanks. In some classes of work, such as large water towers where the concrete is poured fairly wet, movable forms are not used to good advantage on account of the time required for the concrete to harden properly before raising the forms. If the builder is doing very much tank, elevator or silo construction, he usually finds a set of steel forms to represent economy.

Blueprints of figures 74, 77, and 78 to 86, will be gladly furnished at cost of $1.00 per set prepaid. Size 14″x20″.

These drawings give in a clear, simple manner the layout of the forms and are arranged so that they can be used as

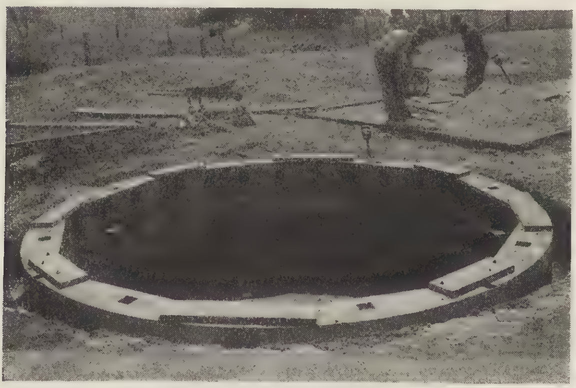


Fig. 90.—Showing circular wood forms.

references or be given to the foreman carpenter. With dimensions inserted the blueprints can serve as working drawings for constructing forms.

TABLE 24
Section Sizes for Circular Forms of Various Diameters and Quantities.

Inner Form					Outer Form
Inside diameter	Number of Sections in Inner Form	Length A	Length B	20-Gauge Gal. Iron 36 in wide, Length of Each Piece	18-Gauge Gal. Iron 36 in. wide, 2 Pcs. Length of Each Piece.
10 ft.	6	5′- 0″	4′- 7½″	5′-2¾″	18′- 3″
12 ft.	8	4′- 6¾″	4′- 1½″	4′-8½″	21′- 5″
14 ft.	8	5′- 4″	4′-11½″	5′-6″	24′- 7″
16 ft.	8	6′- 1″	5′- 9½″	6′-3″	27′- 9″
18 ft.	8	6′-10½″	6′- 7½″	7′-0¾″	30′-10½″
20 ft.	10	6′- 2″	5′-10″	6′-3″	34′- 0″

Material for 14-Foot Silo Form

5 pieces 2 by 12 by 16 feet, for ribs.
1 piece 2 by 12 by 6 feet, for ribs.
4 pieces 2 by 6 by 12 feet, for studding.
6 pieces 2 by 4 by 12 feet, for studding.
4 pieces 2 by 6 by 10 feet, for connections.
3 pieces 2 by 6 by 8 feet, for continuous door form.
2 pieces 2 by 2 by 8 feet, for continuous door form.
64 pieces ½ by 4½ inch carriage bolts.
2 pieces 18 gauge galvanized iron 3 feet wide, 24 feet 7 inches long.
8 pieces 20 gauge galvanized iron 3 feet wide, 5 feet 6 inches long.
Nails, rivets, lugs, hooks, wedges, etc.

Greasing Forms and Moulds for Concrete Construction

The object of greasing wood forms is twofold—first, to waterproof the wood to prevent it from absorbing the water in the concrete, causing swelling and warping; and, secondly, to leave a thin skin of the grease on the surface of the forms to prevent concrete from entering the pores of the wood and adhering to it.

Forms should be thoroughly swept before the reinforcing is placed and kept clean until the concrete is poured. If there is dirt or sawdust on the wood the grease will cover this and not coat the surface of the wood.

The most satisfactory greases are the mineral oils and paraffins. Crude or fuel oil is the cheapest and is satisfactory. It is, however, too thin, except in cold weather, and is best mixed with petroleum grease such as unrefined vaseline. This is placed on the market by all the big oil companies under such trade names as "Petrolatum"—"Product 2259", "Double O", etc., The crude or fuel oil is mixed with this grease in the proportion of one part of grease to three or more parts of oil. The proportion will vary according to temperature, more grease being required in warmer weather. Other materials sometimes used are asphalt paints, varnish, and boiled linseed oil.

For metal forms the cheapest and best grease is plain crude or fuel oil without the addition of the heavier greases. Cold water paint can be used satisfactorily.

Fig. 91.—Greasing forms.

TABLE 25

Table of Board Feet in Various Sizes and Lengths of Lumber. For Use in Estimating Forms and other Timber Work

Size of Timber in Inches	LENGTH OF PIECE IN FEET.							
	10	12	14	16	18	20	22	24
1x 2	1⅔	2	2⅓	2⅔	3	3⅓	3⅔	4
1x 3	2½	3	3½	4	4½	5	5½	6
1x 4	3⅓	4	4⅔	5⅓	6	6⅔	7⅓	8
1x 5	4⅙	5	5⅚	6⅔	7½	8⅓	9⅙	10
1x 6	5	6	7	8	9	10	11	12
1x 8	6⅔	8	9⅓	10⅔	12	13⅓	14⅔	16
1x10	8⅓	10	11⅔	13⅓	15	16⅔	18⅓	20
1x12	10	12	14	16	18	20	22	24
1x14	11⅔	14	16⅓	18⅔	21	23⅓	25⅔	28
1x16	13⅓	16	18⅔	21⅓	24	26⅔	29⅓	32
1x20	16⅔	20	23⅓	26⅔	30	33⅓	36⅔	40
1½x 4	5	6	7	8	9	10	11	12
1½x 6	7½	9	10½	12	13½	15	16½	18
1½x 8	10	12	14	16	18	20	22	24
1½x10	12½	15	17½	20	22½	25	27½	30
1½x12	15	18	21	24	27	30	33	36
2x 4	6⅔	8	9⅓	10⅔	12	13⅓	14⅔	16
2x 6	10	12	14	16	18	20	22	24
2x 8	13⅓	16	18⅔	21⅓	24	26⅔	29⅓	32
2x10	16⅔	20	23⅓	26⅔	30	33⅓	36⅔	40
2x12	20	24	28	32	36	40	44	48
2x14	23⅓	28	32⅔	37⅓	42	46⅔	51⅓	56
2x16	26⅔	32	37½	42⅔	48	53⅓	58⅔	64
2½x12	25	30	35	40	45	50	55	60
2½x14	29⅙	35	40⅚	46⅔	52½	58⅓	64⅙	70
2½x16	33⅓	40	46⅔	53⅓	60	66⅔	73⅓	80
3x 6	15	18	21	24	27	30	33	36
3x 8	20	24	28	32	36	40	44	48
3x10	25	30	35	40	45	50	55	60
3x12	30	36	42	48	54	60	66	72
3x14	35	42	49	56	63	70	77	84
3x16	40	48	56	64	72	80	88	96
4x 4	13⅓	16	18⅔	21⅓	24	26⅔	29⅓	32
4x 6	20	24	28	32	36	40	44	48
4x 8	26⅔	32	37⅓	42⅔	48	53⅓	58⅔	64
4x10	33⅓	40	46⅔	53⅓	60	66⅔	73⅓	80
4x12	40	48	56	64	72	80	88	96
4x14	46⅔	56	65⅓	74⅔	84	93⅓	102⅔	112
6x 6	30	36	42	48	54	60	66	72
6x 8	40	48	56	64	72	80	88	96
6x10	50	60	70	80	90	100	110	120
6x12	60	72	84	96	108	120	132	144
6x14	70	84	98	112	126	140	154	168
6x16	80	96	112	128	144	160	176	192
8x 8	53⅓	64	74⅔	85⅓	96	106⅔	117⅓	128
8x10	66⅔	80	93⅓	106⅔	120	133⅓	146⅔	160
8x12	80	96	112	128	144	160	176	192

Figures given are Board Feet. Lumber is usually priced by the Thousand Board Feet. A piece 1 inch thick, 12 inches wide and 1 foot long constitutes 1 foot Board Measure.

CHAPTER IV. CONSTRUCTION

REINFORCED CONCRETE BUILDING CONSTRUCTION

A reinforced concrete building is monolithic; the foundations, columns, walls and floors are constructed in one solid unit.

There are many different types of foundations, footings, floors and columns in concrete building construction. It is not necessary to understand the technicality of each, but it is essential from the standpoint of construction to have a knowledge of the principles involved.

While this chapter covers small structures particularly, the principles involved will be found useful in reinforced concrete construction generally.

The construction of a reinforced concrete building naturally resolves itself into six divisions:

(1) foundations and footings; (2) floors; (3) columns; (4) roof; (5) walls and partitions; and (6) stairs, elevator shafts, etc.

These six steps, however, have divisions which must be given special consideration for their economical execution, such as:

(1) Form construction, pages 58-82.

(2) Bending and placing of reinforcement, pages 52-58.

(3) Mixing and placing concrete, pages 18-30.

Foundations

Concrete is the material generally employed for all foundation work. It adapts itself to any structural conditions such as irregularity of the bed. It is convenient, strong, durable and reasonable in cost. The same general principles of construction govern in foundation walls whether for large or small buildings.

Forms

The building of forms is shown on page 62. For ordinary trench walls where the ground is solid and firm, forms are commonly built above the ground only, the

trench being made just the width of the wall desired, Fig. 69, page 62. It is a good plan to lay 2″ x 10″ planks flat on the ground along the edge to prevent the earth from being broken off and knocked into the excavation. Sometimes tarred paper or burlap is hung on the side opposite that from which the concrete is poured so as to protect the earth. In the case of cellar walls or basements for buildings when the earth is sufficiently solid and firm to act in place of a form on the outer side, inside forms only are required. Fig. 68, page 62. When the earth is soft, crumbling or yielding, forms are erected on both sides, Fig. 70, page 62 and Fig. 92.

Fig. 92.—Basement wall construction—Conditions required forms for both inner and outer surface of walls. Note piers and footings in foreground and also forms for piers shown on the left.

Construction

Foundation walls are always carried below the frost line, which is at least two feet in southern states and four feet in northern states. The depth of the foundations also depends upon the character of the soil and sufficient depth must be obtained or sufficient width of foundation so as to make sure that there will be no settlement. It is therefore, common practice to have a spread footing for the wall when it is built on soft soil. In addition to having the spread footing, the concrete wall may be reinforced at the lower edge so as to bridge over soft spots.

Reinforced Foundation

A wall so reinforced as shown in Fig. 93 acts as a beam. It, of course, involves careful calculation of the loads so as to secure the right proportion of the wall and footings and the proper amount of reinforcement. Sometimes the concrete basement wall acts as a slab, supported at each end (by the side walls) and on one side (by the floor). When the pressure is considerable the wall should be reinforced accordingly. This condition occurs when there is pressure on the side due to soft soil, or, as is some times the case, due to ground water.

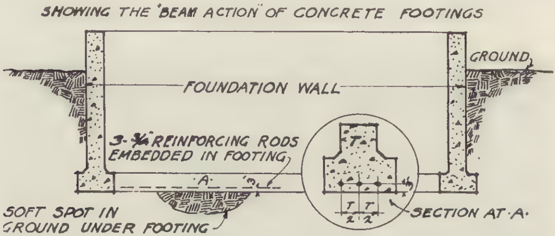


Fig. 93.—How reinforcing can be used to bridge over soft spots.

Size and Mixture

For medium size buildings the basement walls are generally 10 to 12 inches thick. For larger work the thickness is made greater, up to 15 or 18 inches, or reinforcement is used, depending upon conditions. The mixture is 1:2½:5 for ordinary conditions; in case of water pressure a mixture of 1:2:4 should be used. (See page 32). In pouring concrete foundation walls the tendency is to make the concrete too wet, Much better strength and density are secured by using a mixture of only medium consistency described on pages 10-11.

Fastening Superstructure

When building concrete basement walls and footings it is generally necessary to provide some means of fastening the superstructure to the foundation. This can easily be

done by embedding bolts, head down, in the concrete. (Fig. 94).

Fig. 94.—Bolts for fastening down superstructure.

TABLE 26
Table of Materials for 100 Square Feet of Wall

Thickness of wall in Inches	MIXTURE 1:2½:5 Cement Bbls.	1:2½:5 Sand Cu. Yd.	1:2½:5 Pebbles Cu. Yd.	MIXTURE 1:2:4 Cement Bbls.	1:2:4 Sand Cu. Yd.	1:2:4 Pebbles Cu. Yd.
6	2.30	.85	1.70	2.78	.83	1.66
8	3.08	1.13	2.26	3.70	1.10	2.20
10	3.85	1.41	2.82	4.63	1.37	2.74
12	4.60	1.70	3.40	5.56	1.66	3.30
15	5.76	2.12	4.24	6.93	2.06	4.12
18	6.90	2.55	5.10	8.34	2.49	4.98

FOOTINGS

The simplest form of footing construction is plain concrete. It approximates the shape of the old spread masonry footing and is generally used for light structures. The thickness of the plain concrete footing must be sufficient to prevent the column punching through it and the spread of the base should be large enough so that the bearing capacity of the soil is not exceeded. (Figure 95).

Reinforcing is used in a footing in order to decrease the quantity of concrete required as well as to save on the

quantity of excavation. The reinforcing placed in the bottom of the slab prevents its buckling and breaking from the concentrated load of the column. Mixture for footings is generally 1:2½:5.

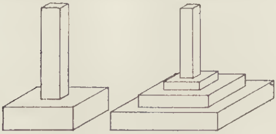


Fig. 95.—Column Footing.

TABLE 27

Bearing Power of Soils in Tons—per Square Foot

	Minimum	Maximum
Rock hardest	200	....
Rock equal to best ashlar masonry	25	30
Rock equal to best brick masonry	15	20
Rock equal to poor brick masonry	5	10
Clay, thick beds, always dry	6	8
Clay, thick beds, moderately dry	4	6
Clay, soft	1	2
Gravel and coarse sand, hard	8	10
Sand, dry, well packed	4	6
Sand, clean, dry	2	4

FLOORS

Plain Floors

Plain concrete floors are of two types—one course and two course. The one course has the advantage over the two course in the saving of labor and materials. Less labor is required for mixing and laying, since there is only one mixture and only one striking off. The one course consists of a uniform mixture throughout—1:2:3. The two course consists of a base of 1:2½:5 and a top course of 1:2 mortar or 1:1:1 using pebbles or crushed stone graded from ¼-inch to ½-inch in size.

In constructing basement floors where good drainage exists, the floor is generally laid right on the ground. If the floor is to be subjected to water pressure the membrane system of waterproofing is used and no joints made. Under heavy pressure the floor is reinforced to resist the upward thrust of the water. In this case the reinforcement would be laid near the top of the slab. The floor may be laid in alternate sections or placed continuously, using strips of

tar paper so as to separate it into sections. Sections usually do not exceed 10 feet square. The customary thickness of basement floors is 4 or 5 inches.

Reinforced Floors

The thickness of the floor depends upon the load to be carried. For short spans see Table 14. In reinforced concrete building construction a smooth finish floor is generally desired. The mortar finish should be 1-inch thick. This is an additional thickness to that of the floor slab required for

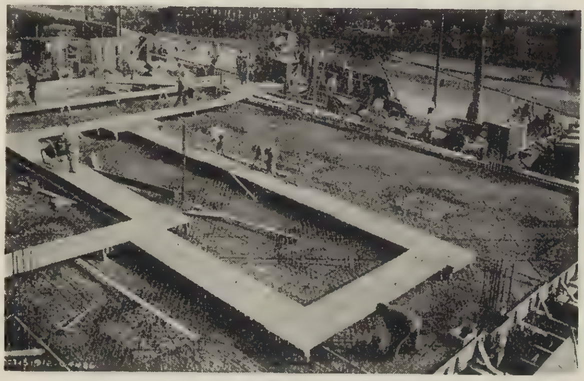


Fig. 97.—View illustrating flat slab construction. This also shows to good advantage the concreting plant and runway for buggies used in depositing concrete.

carrying the load. The finish is screeded with a straight-edge, smoothed with a wooden float and later finished with a steel trowel. If the base has hardened before placing the finish it is very important that it be properly prepared, so that the mortar finish will adhere firmly. It is necessary to roughen the concrete base thoroughly. All loose material should be cleaned from the surface. The concrete should be thoroughly drenched so that it will not absorb any moisture from the finish mortar. The base is then given a coat of grout which is simply cement and water applied with a whitewash brush, and is then

ready for the mortar finish. The mixture for the slab is 1:2:4, and for the finish 1:2, or 1:1:1 as noted above.

TABLE 28

Materials required for 100 Sq. Ft. of Concrete Floor Base

Thickness in Inches	PROPORTIONS								
	1:2:3			1:2:4			1:2½:5		
	Cement Bbls.	Sand Cu. Yd.	Pebbles Cu. Yd.	Cement Bbls.	Sand Cu. Yd.	Pebbles Cu. Yd.	Cement Bbls.	Sand Cu. Yd.	Pebbles Cu. Yd.
3	1.62	.48	.71	1.38	.41	.82	1.15	.43	.85
3½	1.89	.56	.83	1.61	.48	.96	1.35	.50	1.00
4	2.16	.64	.95	1.84	.55	1.10	1.54	.56	1.23
4½	2.43	.72	1.07	2.07	.62	1.24	1.73	.63	1.26
5	2.68	.80	1.19	2.31	.69	1.37	1.92	.70	1.41

TABLE 29

Quantities for 100 Sq. Ft. Wearing Surface or Top Coat

Thickness in Inches	PROPORTIONS				
	1:2		1:1:1		
	Cement Bbls.	Sand Cu. Yd.	Cement Bbls.	Sand Cu. Yd.	Pebbles Cu. Yd.
½	.51	.15	....	....	....
¾	.75	.23	....	....	....
1	1.00	.29	1.00	.15	.15
1¼	1.26	.37	1.26	.19	.19
1½	1.51	.45	1.51	.23	.23
2	2.00	.59	2.00	.30	.30

Terrazzo Floor Finish

Terrazzo floors are used for corridors, halls and display rooms. They are built by using a crushed aggregate, usually marble, graded from $^1/_{16}$ to ½-inch, with portland cement, and polishing when the mixture has hardened sufficiently. A good method is to use 1 part Atlas-White Cement and 2 parts crushed marble, and apply this mortar to the concrete slab to a thickness of ¾ to 1 inch, as in the case of monolithic work. After this mixture has been spread and screeded it is rolled with a roller and additional marble chips added until the mixture will accept no more. The surface is then thoroughly troweled and allowed to

become sufficiently hard to be rubbed with sandstone block or a surface machine. Such a method of construction produces a very attractive, hard, durable floor.

COLUMNS

The columns of a building are the most important individual members and careful consideration in construction is essential. Concrete columns should always be placed first, allowing opportunity for settlement before placing floor slabs. There is more money to be lost or saved in carpenter and labor work on column form construction, erection and stripping than on any other part of the work.

While there are many variations in column shapes, the square column is preferred because the forms are easily and economically built, and can be erected and stripped quickly. The development of steel forms for round columns has decreased the cost of round column construction, however, and there is an increasing use of round columns, especially with flat slab floors where the flare-head column is necessary. If the contractor does not have his own forms, he can rent them. See page 49 on columns, and page 63 on forms. The mixture used in columns should be not leaner than 1:2:4.

Fig. 98.—Floor and column construction showing bars extending above floor level to form lap.

ROOFS

Reinforced concrete roofs are essentially floors (see floors page 92) and are constructed as such. The pitch may be made in the roof itself or drainage may be provided by a cinder fill or cinder concrete upon which is placed tar and gravel, or other form of roof covering. It is considered advisable always to use some form of roofing material on top of the plain concrete slab.

WALLS, PARTITIONS, ETC.

Walls of the skeleton type of reinforced concrete buildings are generally constructed after the skeleton is put up. Slots in the columns are left in order to provide a mortise for the panels. See Fig. 84, page 79 for forms. Ordinary concrete walls require light reinforcing to prevent shrinkage and give them stiffness while setting. Curtain walls of concrete buildings are not designed to carry weight

STEPS AND STAIRS

Forms

Fig. 99 shows forms for concrete steps that are built on the ground and not reinforced. The forms for this type of step construction consist of two planks braced against the side walls by 4 x 4's and wedges. To these are nailed 2 x 4's which come to within a couple of inches of the treads. To the 2 x 4's are nailed the cross planks which form the risers. In actual construction it is better to fasten the 2 x 4's to the planks in their proper position before the planks are braced against the wall.

The forms for the risers can be stripped 24 hours after the concrete is poured and the face of the riser finished to a smooth surface by rubbing with a wood float dipped in water and sand.

Where concrete steps are built without the side walls a different form is used. It is made of planks cut according to the risers and treads of the steps, and the forms for the risers are nailed to the plank. This form is practically the same as for reinforced concrete steps.

Construction

As soon as the concrete base is poured the treads should be finished. The mixture should not be too wet or the concrete at the bottom of the stairs will be forced over the riser forms by the pressure of the concrete above. A 1:2½:5 mixture may be used for the base of the steps with a ¾-inch surface coat of 1:2 mortar.

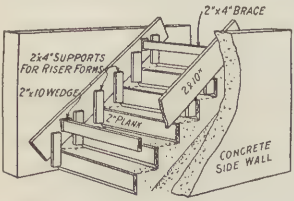


Fig. 99.—Forms for Stairs between Side Walls.

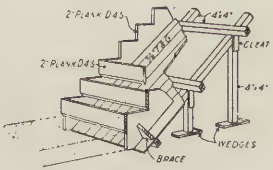


Fig. 100.—Forms for Self-supporting Stairs.

Reinforced Concrete Stairs

Stairs that are not constructed on an earth fill must be self-supporting, and hence, must be reinforced. The reinforcing steel should be placed in the bottom of the slab, one inch from the under side, running lengthwise, and the amount will vary according to the length of the slab. The reinforcing for different length stairs is shown below.

TABLE 30

Table of Reinforcement for Concrete Stairs

No. of Steps	Clear Span		Thickness Slab	Reinforcement	
				Diameter	Spacing Rods
	Feet	Inches	Inches	Inches	Inches
4	2	2	4	¼	10
5	3	0	4	¼	10
6	3	10	4	¼	7
7	4	.8	5	¼	7
8	5	6	5	¼	5
9	6	4	6	¼	5
10	7	2	6	⅜	5
11	8	0	6	⅜	4

Forms

The forms required for self-supporting stairs are shown in Fig. 100. They consist of a panel of ⅞-inch tongue and groove sheathing cleated together, and about 12 to 14 inches wider on each side than the stairs. This panel is supported on 4 x 4's longitudinally, which in turn are supported on 4 x 4″ bents as shown. The planks forming the side forms are nailed to the panels and braced on the outside.

Construction

The entire slab should be poured at one time. The longitudinal reinforcement should be placed before the forms for the risers are attached and the rods in the edge of the steps placed when the concrete is poured. The

Fig. 101.—Stair Construction.

mixture used should be 1:2:4. The placing of the body of the concrete should be followed at once by the ¾-inch surfacing.

The side and riser forms can be removed 24 hours after the concrete is poured, but the forms and shoring supporting the stair slab should be left in place at least four weeks.

Fig. 101 shows three types of riser forms which have proven satisfactory.

Where unusual traffic conditions exist, as in railroad stations and factories, metal treads are used.

A TYPICAL SMALL REINFORCED CONCRETE BUILDING

For Example — A Garage

A construction for garages is described in this section because it is a typical small concrete building. With some slight modification these directions may be used for

tool house, repair shop, small storehouse or for any one of many purposes.

Foundation

For a one-story garage, foundations need not be more than 10 inches thick with a spread foundation if soil conditions warrant; page 90. The common mixture is 1:2½:5.

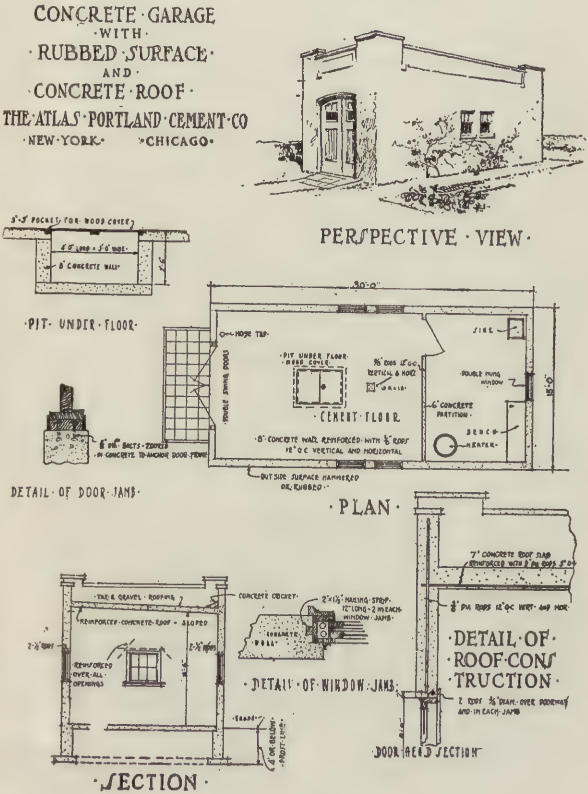


Fig. 102.—Details of Garage Construction.

Walls

A reinforced concrete wall 6 inches thick is satisfactory for the superstructure, using a mixture of 1:2:4. The walls should be reinforced with $\frac{3}{8}$-inch round steel rods, placed 14 inches apart, running horizontally and vertically. Forms for the walls are shown on page 62.

Openings

Window and door openings should be placed in the forms at the time the concrete is being poured. Fig. 71.

Roof

The roof may be made either peaked or flat. The one shown in the drawing has a slope of about 4 inches toward the back of the building. It is made 6 inches thick of a 1:2:4 mixture, and reinforced with $\frac{3}{8}$-inch round steel rods spaced 5 inches apart crosswise, and 9 inches apart lengthwise of the building, and located 1 inch from the bottom of the slab. The rods are wired together where they cross each other so as to prevent any shifting while placing the concrete. A concrete beam 5 inches wide x 14 inches deep, including the thickness of the roof, is placed over the doorway. This beam is reinforced with $\frac{1}{2}$-inch square twisted steel rods, placed 2 inches from the bottom. Forms for the roof consist of a flat platform of 1-inch boards on joists supported by upright studding. Forms are strongly made and well supported so as to safely hold the weight of the wet concrete.

A very satisfactory surface finish may be obtained by employing one of the methods described on pages 39-42.

REINFORCED CONCRETE TWO-STORY GARAGE

Concrete is the ideal material for garage construction. It can easily be handled and makes a thoroughly substantial, rigid and fireproof structure.

The layout and construction details are shown herewith for a two-story garage, which illustrate the application of reinforced concrete to two-story construction.

Forms

The building of forms is described on pages 58 to 82.

Foundations

Foundations in this case were designed for soil pressure of 3 tons per square foot, and are of the plain spread type. The footings of the foundation walls are reinforced in two directions with round steel rods placed within 4 inches of the bottom of the footings. Dowels are used to bond footings to columns and to distribute the load carried by vertical reinforcement of the columns into the concrete.

Columns

The columns are reinforced with vertical steel only, tied together with light hoops, Fig. 60.

Floor Construction

This is beam and girder design. The details are shown in Fig. 103. This type of construction is what is known as monolithic skeleton type.

Roof

The roof is constructed as a floor. A slope is provided by a cinder fill upon which the usual tar and gravel covering is applied.

Walls

The walls are 8 inches thick. Round steel rods are used for reinforcement.

Inclined Runway

The runway is constructed at the same time as the frame work of the building. The pipe railing on the outside is built of 2½-inch piping with standard fittings. The building is shown in Fig. 103. Another type of garage is shown in Fig. 104. Further details on garage construction will be gladly sent. Ask for "Commercial Garages."

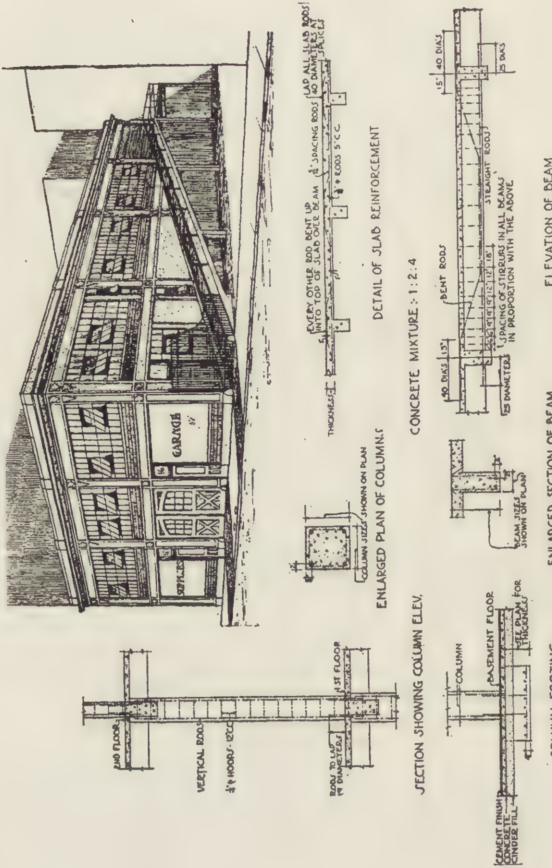
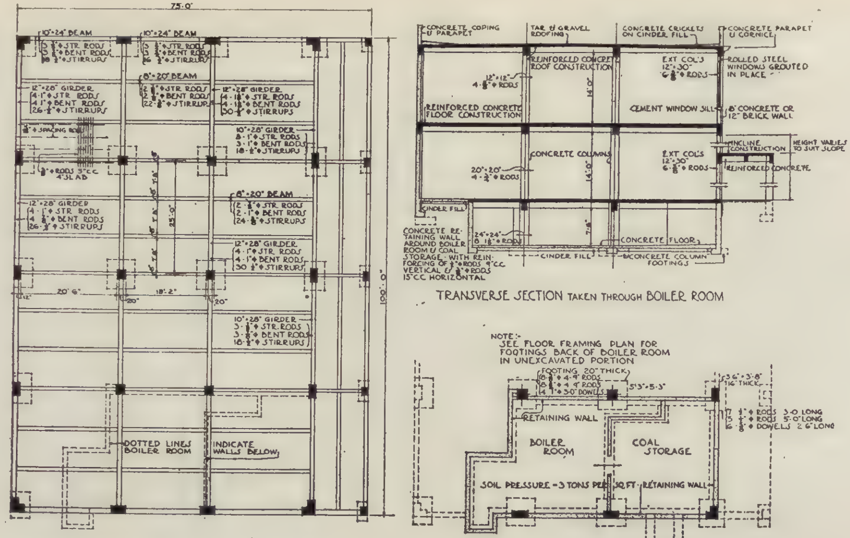


Fig. 103—Details for a 2-story Garage.



FLOOR FRAMING PLAN

TRANSVERSE SECTION TAKEN THROUGH BOILER ROOM

FOUNDATION PLAN TAKEN THROUGH BOILER ROOM

Fig. 103—Plans for the 2-story Garage shown above.

Fig. 104—Reinforced Concrete 2-story Garage.

OPPORTUNITIES IN HOUSE BUILDING AND INDUSTRIAL HOUSES

It is evident that concrete is becoming the standard in house building the same as it has already become in the construction of foundations, sidewalks, roads, factories and other structures. There are many arguments in favor of concrete,—it is weather-proof, fireproof, sanitary, saves painting, upkeep and repairs. It is easily and quickly handled and materials are readily obtained without delays.

Send to The Atlas Portland Cement Company for books describing this form of construction.

TANKS

One of the most advantageous uses of concrete is in the construction of tanks. It combines strength, water-tightness and durability. Concrete tanks are easily constructed and are built in any size or shape.

Concrete tanks are built to hold many different liquids, such as: water, mineral oils, salt brine, molasses, vegetable and animal oils, miscellaneous chemical solutions, tanning liquids and dairy products.

Many of these liquids are stored in plain concrete tanks; others require special treatment on the interior surface. For specific information on solving your storage problem write The Atlas Portland Cement Company.

Construction

The general principles of construction, such as foundations, mixture, placing, etc. are the same for all tanks. The kind and shape of forms vary and also the thickness of walls and the amount of reinforcement.

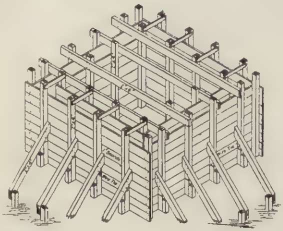


Fig. 105.—Forms and Bracing Required for Concrete Tank Construction.

The location must first be determined in order to decide upon the proper shape and design of the tank. In selecting the size it should be remembered that 7½ gallons equal one cubic foot. The size of tanks runs from small watering troughs of a few barrels to large tanks or reservoirs holding many thousand gallons.

Foundations

The best foundation is a thoroughly and uniformly compacted soil evenly supporting the entire tank floor. In soft soil it may be necessary to dig trenches and build foundation walls. In such cases additional reinforcing should be used in the floor.

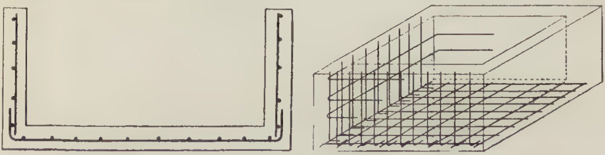


Fig. 106.—Details of Reinforcement, Showing Bends and Turnups in Corners.

Forms

Forms for rectangular or square tanks are shown in Fig. 105. In circular tank construction of large size either movable forms are used as shown in Fig. 89 or

forms for the entire height. If a contractor has several tanks to build, steel forms are generally more economical than wood.

TABLE 31
Reinforcement for Bottom of Rectangular Tanks
For circular tanks wire mesh is used

Depth of Tank	Thickness of Floor	Spacing of 3/8″ round rods.	Spacing of 1/2″ round rods.	Spacing of 3/4″ round rods.
Feet	Inches	Inches	Inches	Inches
3	6	10	....	....
4	6	8	16	....
5	7	7½	15	....
6	7	7	14	....
7	8	6½	13	....
8	8	6	12	24
9	10	5	10	20
10	10	4	8	16

TABLE 32
Size and Spacing of Rods in Walls of Rectangular Tanks

Depth of Tank	Thickness of Wall	Spacing of 3/8″ round rods.		Spacing of 1/2″ round rods.		Spacing of 3/4″ round rods.		Spacing of 1″ round rods.	
		Vertical	Horizontal	Vertical	Horizontal	Vertical	Horizontal	Vertical	Horizontal
Feet	Inches	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
3	5	5	10	10	20	.....	.....	.....	.....
4	5	4	8	8	16	16	32	.....	.....
5	5½	3	6	6	12	12	24	.....	.....
6	6½	2½	5	5	10	10	20	18	36
7	8	.....	.....	3	6	7	14	16	30
8	9½	.....	.....	2½	5	5	10	11	22
9	10½	.....	.....	.....	.....	5	10	10	20
10	12	.....	.....	.....	.....	4	8	8	16

TABLE 33
Size and Spacing of Rods in Walls of Circular Tanks.

(1) Depth	(2) Diameter	(3) Thickness of Concrete in wall	(4) Diameter of Horizontal Rods	(5) Spacing Horizontal Rods at bottom	(6) Spacing Horizontal Rods at top	(7) Diameter Verti-Rods	(8) Spacing Vertical Rods
Feet	Feet	Inches	Inches	Inches	Inches	Inches	Inches
5	5	6	¼	8	18	¼	36
5	10	6	¼	6	12	¼	30
10	10	8	⅜	6	18	⅜	36
10	15	9	⅜	4	18	⅜	36
15	10	10	⅜	4	18	⅜	30
15	15	12	½	6	20	⅜	30

Proportions

The proportions must be such as to secure a thoroughly dense concrete that will be water-tight. Usually for ordinary work a 1:2:4 mixture is used. For special work richer mixtures are necessary. See page 31 on water-tight concrete.

Placing

Concrete should be placed continuously if possible; otherwise, care should be taken to secure proper bond with the previously poured concrete. See page 38.

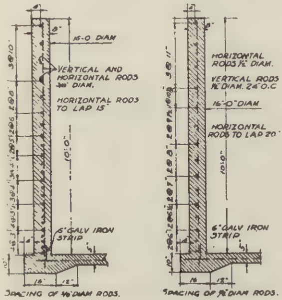


Fig. 107.—Details Showing Arrangement of Reinforcing Rods in Circular Tank.

Joints

There are several ways of making joints. About the most common is the use of a metal dam. This is a piece of sheet metal 6 inches wide, placed vertically and buried 3 inches deep in the old concrete, extending 3 inches into the new concrete.

Quantities of Materials Required for Tank—Fig. 108

	Concrete, 22½ Cu. Yd. Mix 1:2:3			
	Cement Sacks	Sand Cu. Yd.	Stone Cu. Yd.	Reinforcement
5½" Roof Slab..	28	2	3¼	½" rods—478 lb.
Floor............	39	3	4¼	¼" rods—67.7 lb. or wire mesh 42" wide—84.5 lb.
Walls...........	91	6¾	10¼	⅜" rods—663 lb. or ½" rods—705 lb.
For 7" Roof Slab use these quantities..........	36	2¾	4½	⅝" rods—625 lb.

Reinforcement

Reinforcement for rectangular and circular tanks is shown in the tables on page 106. All reinforcement must be carefully placed in proper position. It is put in

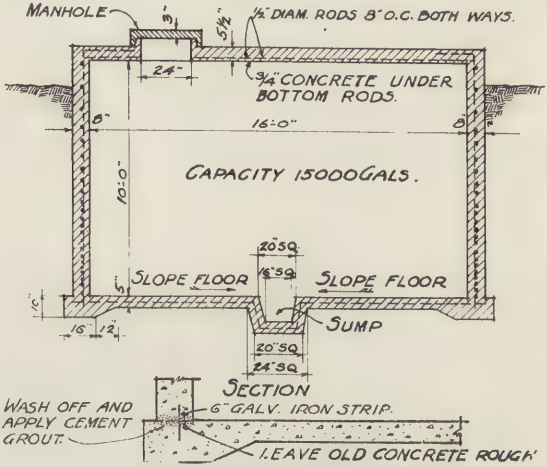


Fig. 108.—(Section of Circular Tank).
Detail of Joint between Floor and Wall. (Reinforcement omitted in sketch to show construction more clearly).

TABLE 34
Approximate Capacity of Round Silos

Height of silo	Inside Diameter of Silo in Feet and Capacity in Tons					
	10 Feet	12 Feet	14 Feet	16 Feet	18 Feet	20 Feet
Feet	Tons	Tons	Tons	Tons	Tons	Tons
28	42	61	83	....	....	....
30	47	67	91	....	....	....
32	51	74	100	131	....	....
34	56	80	109	143	....	....
36	61	87	118	155	196	....
38	66	94	128	167	212	....
40	70	101	138	180	229	280
42	....	109	148	193	244	299
44	....	117	159	207	261	320
46	....	....	170	222	277	340
48	....	....	....	236	293	361
50	....	....	....	....	310	382

the center of the wall as shown in Fig. 106, and the bars are lapped at the junction of the bottom and sides, and around the corners. If necessary to splice the bar, they should be lapped 40 diameters.

Fig. 109.—Monolithic Concrete Silo 12'x42'.

CONCRETE SILOS

A concrete silo means a big saving for the farmer. It saves at least 40% of the corn crop by saving the stalks which would otherwise be wasted. Few farmers are equipped to build their own silos; most of them prefer to have this kind of construction handled by contractors. Concrete silos provide a safe and sure protection for the silage. They have been used in all parts of the country with great success, and are recom-

TABLE 35
Quantity of Concrete Material for Monolithic Silos of Various Diameters

These figures include footings and floor, but not roof. Walls 6 inches thick. Continuous doors 2 feet wide. Figures are based on a 1:2½:5 mix for the foundation and 1:2:4 for the walls.

Inside diameter Feet	For Silo 30 Feet High			For Each Additional 5 Ft. in Height		
	Cement Bbls.	Sand Cu. Yd.	Pebbles or stone Cu. Yd.	Cement Bbls.	Sand Cu. Yd.	Pebbles or stone Cu. Yd.
10	29	11	18	4.0	1.5	2.4
12	35	13	21.5	5.0	1.8	2.9
14	41	15	25	5.5	2.1	3.4
16	47	17.3	28.7	6.4	2.4	3.8
18	53	19.6	32.6	7.2	2.7	4.3
20	59	22	36.5	8.1	3.0	4.8

mended by the State Agricultural Colleges. For forms see page 83.

TABLE 36

Spacing of Horizontal Re-inforcing Rods for Silos of Various Inside Diameters

Distance in feet down from top of Silo	10-foot diameter ⅜-inch Round Rods	12-foot diameter ⅜-inch Round Rods	14-foot diameter ½-inch Round Rods	16-foot diameter ½-inch Round Rods	18-foot diameter ½-inch Round Rods	20-foot diameter ½-inch Round Rods
	Inches	Inches	Inches	Inches	Inches	Inches
Top 5 ft.	24	24	24	24	24	24
5 to 10	24	24	24	24	24	24
10 to 15	24	18	24	24	24	24
15 to 20	18	16	24	18	18	16
20 to 25	16	12	18	16	14	14
25 to 30	14	10	16	14	12	12
30 to 35	12	9	14	12	10	10
35 to 40	10	8	12	10	9	8
40 to 45	9	7	11	9	8	7½
45 to 50	8	6½	10	8½	7½	7

If square rods are used increase spacing 20 per cent. but in no case should spacing be greater than 24 inches.

Further information on silos will be gladly furnished you by The Atlas Portland Cement Company.

SMALL GRAIN ELEVATORS

A small concrete grain elevator is almost identical in construction with the ordinary concrete silo or circular tank. The only additions needed are a concrete pit for the bucket elevator boot and a work-house on top of the bin or bins to house the elevator head and chutes.

TABLE 37

Capacity of Grain Bins and Tanks—In Bushels.

Height	Diameter in Feet							
	10	12	14	16	18	20	22	24
30	1892	2730	3715	4840	6125	7575	9180	10630
35	2208	3185	4340	5650	7145	8840	10700	12400
40	2525	3640	4950	6460	8170	10018	12240	14560
45	2840	4095	5570	7270	9190	11350	13780	16380
50	3158	4550	6195	8080	10210	12620	15300	18200
55	......	5005	6814	8888	11231	13882	16830	20020
60	......	5460	7433	9696	12252	15144	18360	21840
65	......	......	8053	10504	13273	16406	19890	23660
70	......	......	8672	11312	14294	17668	21420	25480
75	......	......	9293	12120	15315	18930	22950	27300
80	......	......	......	12928	16336	20192	24480	29120

Fig. 110 shows a cross section of a one-bin concrete grain elevator. The operation of such an elevator is as follows: The farm wagon dumps its load of grain into the boot-pit and the bucket-elevator raises the grain to the top of the bin where it is discharged through the bin chute into the bin. When a railroad car is to be loaded the bin gate is opened and the grain flows into the pit from which the bucket elevator raises it to the top and it is discharged, this time through the car chute into the railroad car. Table 37 gives the capacities of elevators in bushels. For further information inquire of The Atlas Portland Cement Company.

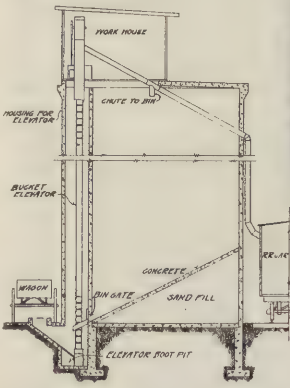


Fig. 110—Cross-section of a One-bin Grain Elevator in its simplest form. Built with silo forms.

Fig. 111—Grain Elevator. Bin—26′ inside diameter—80′ high. Work house 10′ x 12′. Cement blocks were used for warehouse and engine room.

SWIMMING POOLS

Towns and cities are building swimming tanks and wading pools in athletic fields and parks for both adults and children. Many towns and cities offer opportunities to contractors for promoting and building such pools. No other material is as suitable as concrete.

Swimming pools are built in various sizes, usually not smaller than 45 feet long by 15 feet wide. A common size and one which will fit the majority of cases is 60 feet long by 20 feet wide, a suggested design for which is shown in Fig. 112.

Forms

Footing forms are first erected allowing sufficient space for tile drain around the outer edge of the pool as indicated in the drawing. The reinforcing is then placed for the walls and temporarily held by supports. Forms are then built for the entire height of the walls.

Mixture and Placing

The mixture should be not leaner than 1:2:3. See page 31 on water-tight concrete. The concrete should be placed in 9-inch layers and puddled thoroughly, and spaded well next to the forms. After the interior forms have been removed the wedge shaped strips which will form a space to be filled with tar, are placed around the edge and construction of the floor carried on. If the floor cannot be placed continuously, the concrete should be laid in sections and joints provided. Floor construction is described on page 92.

Reinforcement

Details on the placing and bonding of steel are given on pages 49 to 58.

Finish

If weather conditions allow the inner forms to be removed within 24 hours, the concrete can be roughened with a wire brush and surfaced with a mortar composed

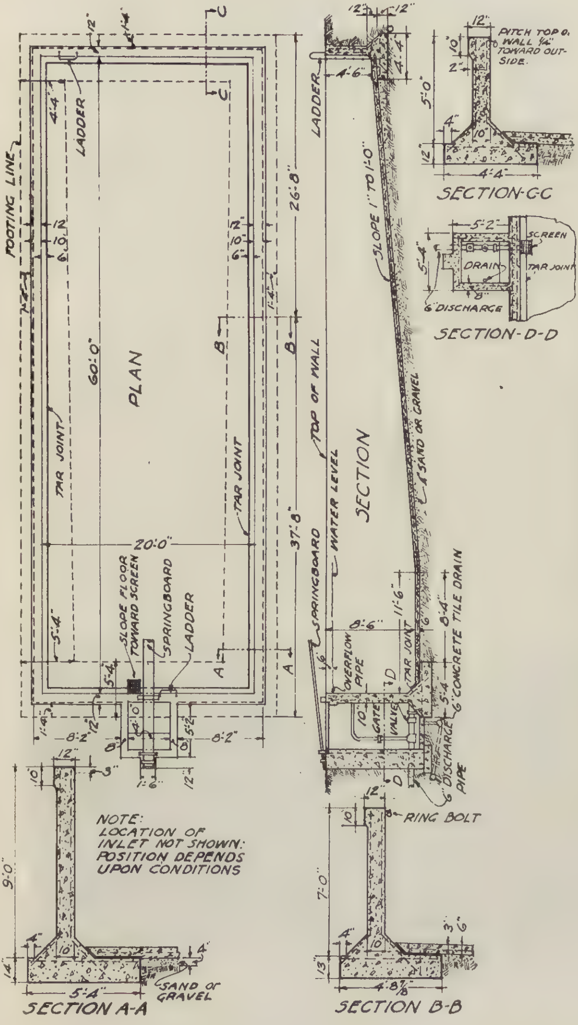


Fig. 112—Plans for a Swimming Pool.

of 1 part Atlas-White Cement, and 2 parts white sand, or crushed marble. If the forms are allowed to remain for a longer time, the surface should be thoroughly roughened with a stone pick or similar tool before applying the finish. Such a finish has a very attractive appearance; see pages 39-42 on surface finishes.

It is advisable to wait at least 3 weeks before back filling with earth, or allowing the tank to be filled with water. Details on swimming tanks of other size, and further details on construction will be gladly furnished by The Atlas Portland Cement Company.

Materials required for 20 Ft. x 60 Ft. Swimming Pool

Cement	175 Barrels
Atlas-White Cement (for Finish coat)	5 Barrels
White Sand	1½ Cu. Yds.
Sand	52 Cu. Yds.
Crushed Stone or Pebbles	78 Cu. Yds.
Reinforcement	4850 pounds
Form lumber if purchased for this work alone	6000 Bd. Ft.

Fig. 113—Concrete Swimming Pool Lined with Atlas-White Portland Cement.

STORAGE CELLARS

Storage cellars are usually built underground or two-thirds underground with either a flat or an arched roof.

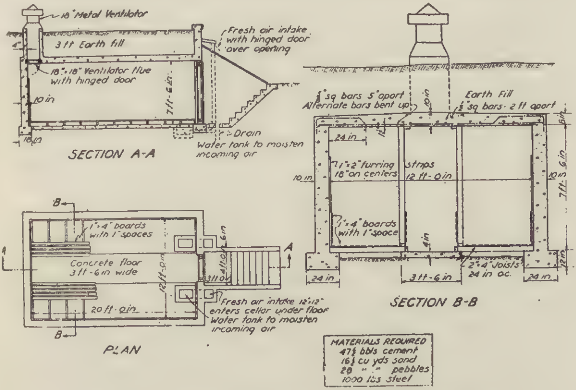


Fig. 114—Concrete Storage Cellar with Flat Roof.

Forms

The principles of form construction are described in Chapter III beginning on page 58 and apply to the building of storage cellars. The construction of forms for the arched roof is more complicated than for a flat top and plans may be secured by writing to The Atlas Portland Cement Company.

Construction

Construction details are shown in Figures 114 and 115. The concrete should be mixed in the proportion of 1:2:4 except for the arched roof which should be 1:2:3.

The concrete should be well puddled in the forms and spaded next to the surface, especially if the storage cellar is partly above ground, so as to provide a good surface.

Roof

Reinforcing steel must be used in the roof of a cellar with a flat top. For a cellar such as that shown in Fig. 114,

bars ⅝ inch square are spaced 5 inches apart, center to center, and placed 1½ inches from the bottom of the slab. Alternate bars are bent up at a point 2 feet from the inside cellar wall. The ends of all bars are bent at right angles to form a hook about 3 inches long. This insures good anchorage in the concrete. One-half inch square bars placed 2 feet apart are run lengthwise.

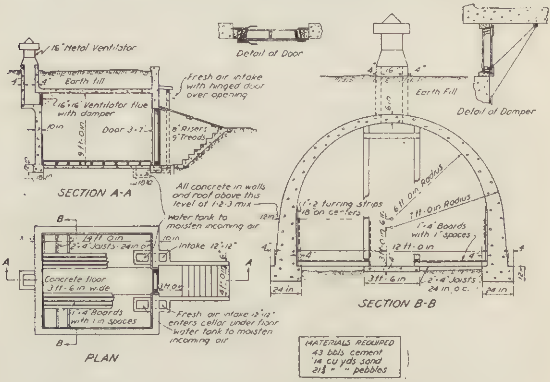


Fig. 115—Concrete Storage Cellar with Arch Roof.

SEPTIC TANKS

A septic tank is a modern and sanitary means of disposing of sewage and household waste. It is made of concrete usually with two compartments.

Fig. 118 shows the general lay-out, and Figures 116 and 117 show plans of septic tanks which are designed to take care of the requirements of the average household including up to eight people.

Forms

The general principles of form construction are described in Chapter 3 beginning on page 58, and these apply to the building of septic tanks.

Mixture

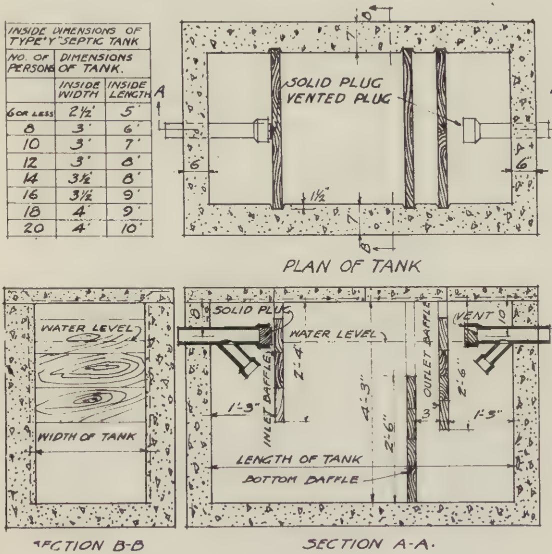
The mixture should be 1:2:3.

Placing

If possible the concrete should be placed continuously so as to avoid joints. It should be well puddled and thoroughly worked in and around the reinforcement. Size of the pebbles or crushed stone for this class of work usually runs from ¼-inch to 1¼-inches.

Reinforcement

Rods or heavy wire mesh may be used for reinforcing. Fig. 117 shows size and spacing. Reinforcement must be securely tied so as not to be pushed out of place when the concrete is poured.



INSIDE DIMENSIONS OF TYPE "Y" SEPTIC TANK		
NO. OF PERSONS	DIMENSIONS OF TANK.	
	INSIDE WIDTH	INSIDE LENGTH
6 OR LESS	2½'	5'
8	3'	6'
10	3'	7'
12	3'	8'
14	3½'	8'
16	3½'	9'
18	4'	9'
20	4'	10'

Fig. 116.—Type Y septic tank as designed by Department of Rural Engineering, N. Y. State College of Agriculture.

Roof

The roof or top of the tank must be built sufficiently strong to resist the weight that it will have to carry. Sometimes the tanks are underground and have earth on top of them. At other times they are so situated that they will be driven over, and must be designed to support loads accordingly. A man-hole should be provided for cleaning purposes.

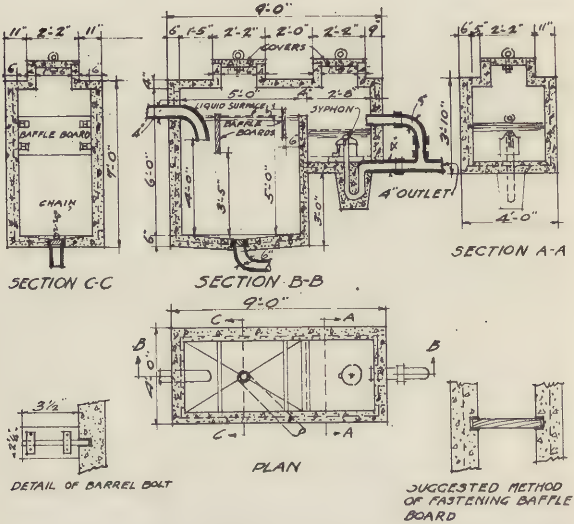


Fig. 117.—A Suggested Design for a Septic Tank.

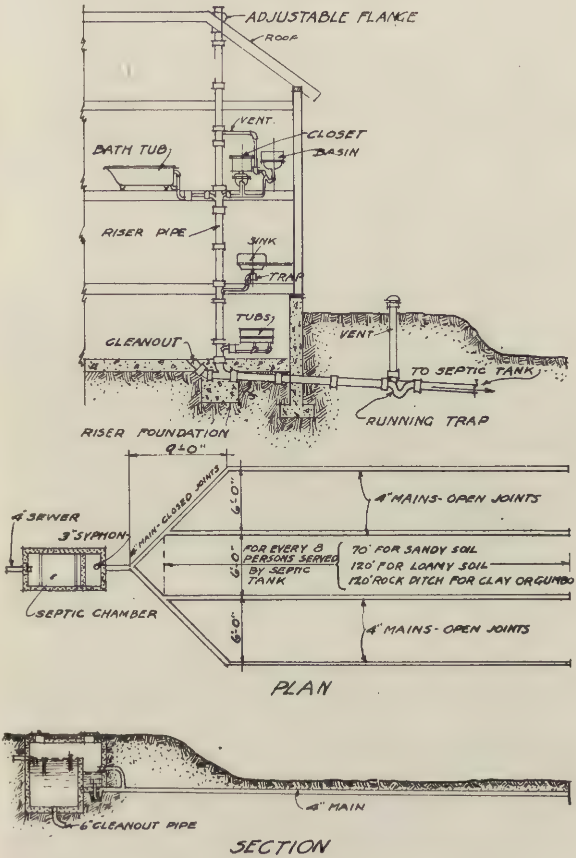


Fig. 118—General Plan of Plumbing and Septic Tank.

SIDEWALKS

Concrete sidewalks are built either of the one course or two course type. The one course has the advantage. It is of uniform mixture throughout, which means that the cost of mixing and placing is less.

Foundations

The kind of foundation depends on the character of the soil. If the soil is sandy or well-drained, an excavation is made only for the depth of the slab. The soil is then thoroughly tamped and wetted.

If the soil retains water, an excavation of from 10 to 12 inches is made and from 6 to 8 inches of cinders laid and thoroughly rammed. When this method is followed,

Fig. 119.—Float Finishing.

drainage should be provided to carry off the water which might otherwise remain in the foundation and cause injury by freezing.

All tree roots should be removed to sufficient depth so that no injury by upheaval can result from them.

Forms

2″ x 4″s or 2″ x 6″s set in place and securely staked provide suitable forms.

Expansion Joints

Expansion joints ½ inch wide should be placed every 50 feet, or ¼ inch joints every 25 feet. If the walk runs

to the curb, a joint should be placed between it and the walk. Joints consist of prepared material, such as asphaltic felt. The usual length of a slab or unit is 5 feet; a complete separation should be made between successive slabs.

Finish

A slightly rough finish is obtained by using a wooden float. This is usually preferable to the very smooth finish secured by using a steel trowel.

Excess water should be avoided, see page 10; also excessive troweling, which brings the cement and water to the surface and causes dusting with the result that the sidewalk will not wear as well as it would otherwise.

Protection

The concrete should be protected by covering or sprinkling so as to prevent too rapid drying out.

Mixture and Thickness

One course sidewalk is built of a mixture of 1:2:3 and is usually 5 inches thick.

Two course sidewalk is built of 1:2½:5 for the base; and one part Atlas Cement and 2 parts sand for the top. The base is commonly 4 inches thick, and top 1 inch thick. For quantity of materials see page 92 under subject of floors.

CURBS AND GUTTERS

Concrete is the material commonly used for curb and gutter construction. It is adaptable to any form or shape, and can be built at the same time as a driveway or pavement.

Both two-course and one-course construction are used, but the tendency now is toward one-course work—the same mixture throughout. It is easier and more economical to handle. A good finish can be obtained by properly tamping and spading the concrete and then removing the forms as soon as possible and troweling the surface.

The single curb is usually built 6 to 8 inches thick at the top and 9 to 12 inches thick at the bottom, and 18 to 24 inches deep. Fig. 120 shows how forms are constructed and braced.

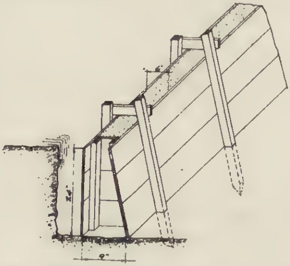


Fig. 120.—Forms for Single Curb.

Fig. 121 shows the size of curb and construction of forms for combined curb and gutter; also for curb combined with concrete driveway.

If soil requires a sub-base, gravel or cinders to a thickness of 6 inches may be used. The concrete should consist of 1:2:4 mixture with particles not larger than 1½ inches for one-course work.

Expansion joints are provided by inserting prepared sheets of asphaltic felt, allowing a joint of at least ½ inch every 50 feet. The curb should be built in sections as in sidewalk construction by using a steel dividing plate at intervals of not more than 10 feet.

Both the curb shown in Fig. 120 and the curb and gutter shown in Fig. 121 have the same cross-section area. Hence, the quantities required per 100 lineal feet are the same—7 barrels cement, 2 cubic yards sand, 4 cubic yards pebbles.

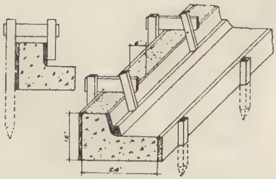


Fig. 121.—Forms for Curb and Gutter.

CONCRETE DRIVEWAYS

Concrete is commonly used for driveways to garages, around the house and barns, and about industrial plants, also for alleys, roads and pavements generally.

This construction is permanent, non-slippery, dustless, uniform of surface, easily cleaned and reasonable in cost.

TABLE 39

Amounts of Materials for Concrete Driveways and Concrete Bases per Square Yard

	MIXTURE														
	1:1½:3			1:2:3			1:2:4			1:2½:5			1:3:6		
Thickness Inches	Cement Bbls.	Sand Cu. Yd.	Pebbles Cu. Yd.	Cement Bbls.	Sand Cu. Yd.	Pebbles Cu. Yd.	Cement Bbls.	Sand Cu. Yd.	Pebbles Cu. Yd.	Cement Bbls.	Sand Cu. Yd.	Pebbles Cu. Yd.	Cement Bbls.	Sand Cu. Yd.	Pebbles Cu. Yd.
5	.265	.058	.116	.242	.073	.107	.210	.063	.126	.173	.066	.132	.147	.067	.134
6	.318	.070	.140	.290	.087	.128	.258	.075	.150	.206	.077	.154	.177	.078	.156
7	.372	.081	.163	.338	.101	.150	.294	.087	.175	.241	.089	.179	.206	.091	.183
7.33	.389	.086	.173	.355	.106	.157	.308	.092	.184	.254	.094	.188	.216	.096	.192
8	.425	.093	.189	.389	.116	.171	.335	.100	.197	.275	.103	.206	.229	.105	.210
9	.477	.105	.210	.435	.130	.193	.377	.113	.225	.310	.115	.230	.265	.118	.235

Driveways with flat base and crowned surface 6″ at side and 8″ at center have a thickness of 7.33″.

Fig. 122 shows cross sections for the three different types of driveway construction.

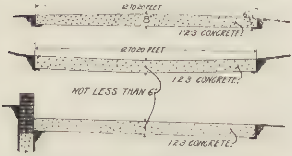


Fig. 122.—Cross Sections for Driveways.

The mixture commonly used is 1:2:3.

Write The Atlas Portland Cement Company for further information on driveways and industrial plant roadways.

Fig. 123.—Good Roadways for Industrial Plants are a Necessity.

ENGINE FOUNDATIONS

Engine foundations of concrete are strong, rigid and permanent.

A good solid footing must be obtained so that no settlement of the foundation can take place. The foundation itself must be large and massive enough to hold the engine firmly without vibration.

Forms

The form is really a bottomless box, shown in Fig. 124. Bolts for fastening the engine to the foundation are held in place by means of a template, also shown in Fig. 124.

Fastening Engine to Foundation

Bolts should extend at least a foot into the concrete and have large iron washers at the lower end. Pieces of pipe at least twice the diameter of the bolts allow for a slight adjustment. After the bolts are in position the spaces between them and the pipe are filled with a 1:1 mortar. The mixture for the foundation should be 1:2:4. The concrete should harden at least a week before placing the engine on the foundatoin, and two weeks should elapse before the engine is allowed to run.

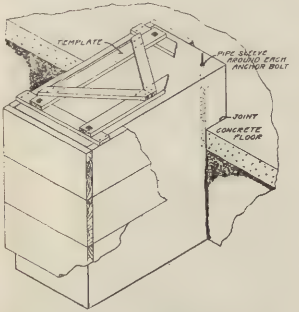


Fig. 124—Concrete Engine Foundation Showing Template and Bolts in place.

Fig. 125.—Photo of Large Engine Foundation.

CULVERTS AND SMALL BRIDGES

Culverts to be satisfactory must be strong, lasting, free from repairs and decay. No other material meets these requirements so well as concrete. Size may be determined by measuring the width and depth of the stream during high water, and comparing the results arrived at, if possible, with culverts over the same stream in the same

neighborhood. The opening of a culvert should be sufficient to take care of the flow during high water.

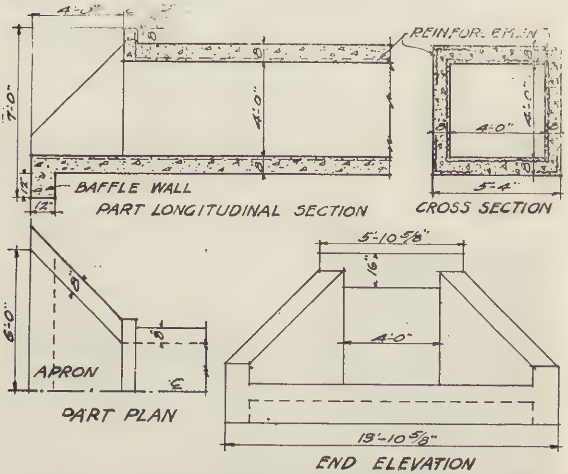


Fig. 126—Box Culvert 4′ x 4′.

For small openings concrete pipe is generally used. In the case of larger openings the box or arch culvert is the best. A slope of ¼-inch per foot in the direction of flow is sufficient for the floor of the culvert.

Box Culverts

Box culverts are built of square or rectangular cross sections. Fig. 126 shows a good design for a box culvert. It is of square section, with bottom baffle wall and apron at each end to prevent undermining.

Forms

Forms for box culverts are very simple and can be built by following the general directions on pages 58 to 62. The outside forms are set up first, then concrete poured for the bottom, and the inside forms next set in place. Collapsible forms represent economy if many culverts are to be built.

Mixture

Mixture for culverts is commonly 1:2½:5.

Reinforcement

Figure 127 shows details and reinforcement for a 6-foot culvert. All rods are ⅝-inch in diameter. In both

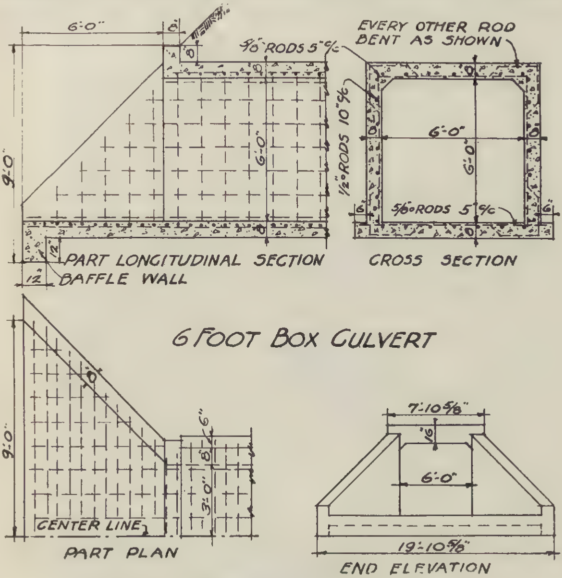


Fig. 127.—Reinforced Concrete Box Culvert.

top and bottom, rods are placed cross-wise spaced 5 inches apart. For the top arch alternate rods are bent up as shown. Vertical rods are spaced 10 inches apart on both sides. Rods in the apron are spaced 5 inches apart and bent up alternately so that the vertical rods in the wing wall are spaced 10 inches apart. Longitudinal reinforcement consists of ½-inch diameter rods on 10 inch centers.

Arch Culverts

Arch culverts, while more difficult to build than box culverts, have certain obvious advantages. Figures 128, 129, 130 show designs for five, eight, and ten foot clear spans, respectively, where soil is solid and firm such as sand or hard clay. If built in soft soil the area of the footing should be increased so as to provide sufficient bearing.

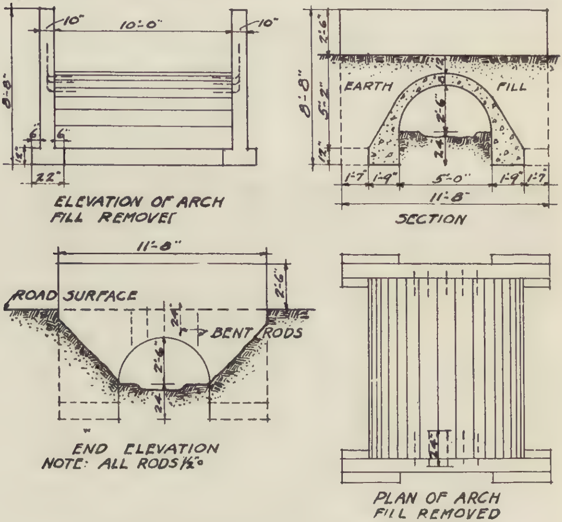


Fig. 128.—Arch Culvert for Five-foot Span.

Forms

Forms are made as shown in Fig. 131. For further information on forms see pages 58-62.

Mixture

If good aggregates are obtainable, the mixture may consist of 1:2½:5. Reinforcement must be carefully placed as shown, and held rigidly in position.

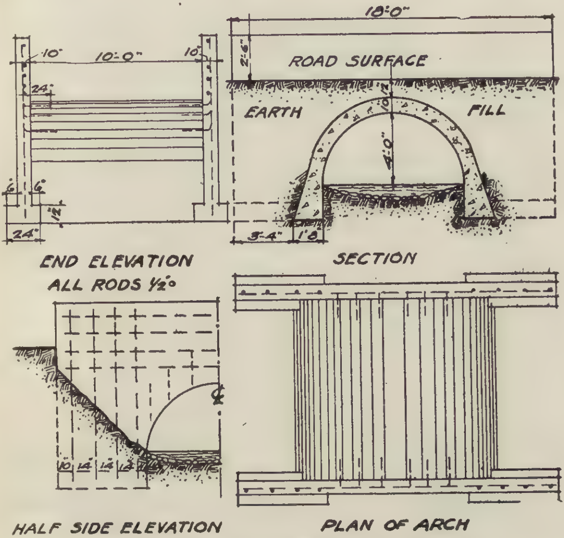


Fig 129.—Arch Culvert for Eight-foot Span.

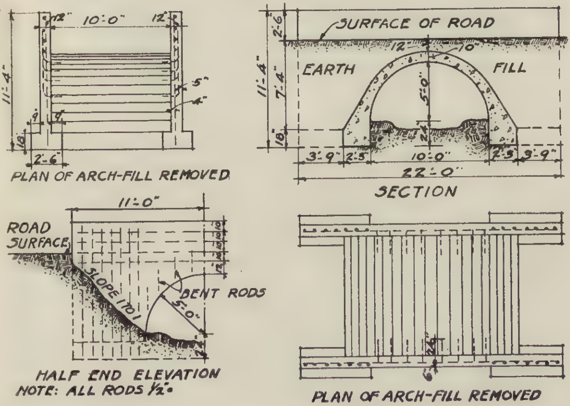


Fig. 130.—Arch Culvert for Ten-foot Span.

Quantities

Quantities of materials are as follows:

TABLE 40

Mixture 1:2½:5

Span of Culvert	10 Foot Roadway			Extra material for each additional foot width.		
	Cement Bbls.	Sand Cu. Yd.	Pebbles Cu. Yd.	Cement Bbls.	Sand Cu. Yd.	Pebbles Cu. Yd.
5	12½	4½	9	½	⅕	⅖
8	20	7	14	¾	¼	½
10	28¾	10¼	20½	1	⅓	⅔

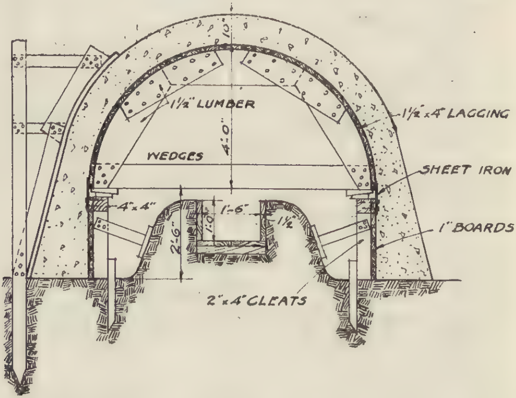


Fig. 131.—Forms for Eight-foot Circular Arch.

CONCRETE RETAINING WALLS

On account of the low cost, the great strength and adaptability of concrete, retaining walls are usually built of this material.

Types

There are a number of different types of retaining walls. The following three are most commonly used:

The GRAVITY wall, which is perhaps the most common type and requires no complicated reinforcing. It

depends upon its own shape and weight to resist the earth pressure. It is the simplest to construct and for walls under 20 feet in height, is often the most economical.

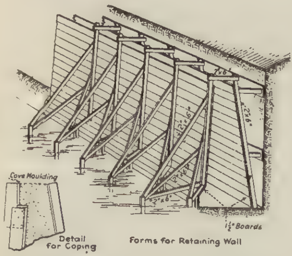


Fig. 132.—Forms for Retaining Wall. Space back of the form (to the right) to be filled in after wall is completed. To the left, below, form for a top molding or coping.

The CANTILEVER reinforced wall in which the weight of the earth behind the wall is utilized to prevent overturning. This wall requires very heavy and careful reinforcing.

The COUNTERFORT wall, in which buttresses are built at short intervals, tieing the floor portion, which is held down by the weight of the earth to the vertical portion of the wall.

Foundation

Excavate to below frost line and to firm enough soil to withstand the pressure at the toe of the wall due to tendency to overturn.

Size

A common rule for gravity walls is to make the base 4/10 as wide as the height of the wall. The front of the wall is usually given a slope, or batter, of 1 inch to 2 inches per foot of height. The back of the wall on the earth side should be preferably stepped.

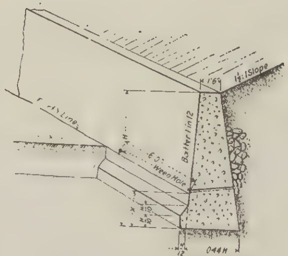


Fig. 133.—Dimensions for Retaining Wall, less than 20 feet high "H" means height; other dimensions are given in terms of height.

Forms

Forms may be constructed of $1\frac{1}{2}$ inch or 2 inch lumber, held in place by 2 x 6 inch bracing and struts. The struts are nailed to stakes driven in the ground, as shown in Fig. 132.

Mixture

Concrete is made of a $1:2\frac{1}{2}:5$ mixture.

Coping

Coping always adds to the appearance of a concrete retaining wall. The coping projects 2 or 3 inches beyond the face, and is from 8 to 18 inches high, depending on the height of the wall. Its corners should be beveled or rounded, which is done by nailing a triangular strip or a cove-molding in the forms. It is better to build the coping at the same time as the rest of the wall, but if this is not possible, it can be done later.

Drainage

Of especial importance is the drainage of water from the earth held by the wall. A layer of loose stones, gravel, or cinders, should be placed directly behind the wall, and weep holes from 6 to 10 feet apart should be provided. These can be made by inserting during construction 3 or 4 inch drain tile at the earth line at the face of the wall, as shown in Figure 133. Back filling should be carefully done, soil being thoroughly compacted. The earth is deposited in layers about 8 inches thick, depending on the character of the material, each layer being tamped before the next layer is placed.

Finish

Since retaining walls do not withstand any pressure during construction, the forms can be stripped as soon as the concrete has set enough to sustain its own weight. This allows the most economical and satisfactory finishing, which is accomplished by simply rubbing with a wooden float dipped in water and sand. In this way the form marks are rubbed off and a smooth and absolutely permanent surface is obtained.

CEMENT PRODUCTS

The name "cement products" is given to concrete building units which are small enough to be pre-cast (cast before setting in place) in a factory. In this class are:

Building Block	Concrete Silo Staves
Brick	Drain Tile and Pipe
Sills and Lintels	Floor Tile
Building Trim	Cement Shingles
Roof and Wall Tiles	Fence Posts
Blocks for Stucco	Sign and Lamp Posts

To properly manufacture cement products it is necessary to have a good plant, well equipped with the necessary moulds and machines. Unless you have such a plant, it will be best to purchase the cement products you require from an established manufacturer in your locality.

Concrete blocks as a base for stucco, however, may often advantageously be made on the job instead of in the factory. While blocks for this purpose should be well made the surface finish is of secondary consideration, a rough surface being more desirable.

Concrete fence posts are as low in cost as the best quality of wood posts, are strong and do not rot nor burn.

Fig. 134.—Example of use of Concrete Units in House Construction.

Post moulds can be made of wood, or sheet metal moulds may be purchased. The metal moulds are better.

For further information on cement products and the names of manufacturers of moulds and machines, write The Atlas Portland Cement Company.

CHAPTER V.

HOW TO ESTIMATE COSTS OF REINFORCED CONCRETE CONSTRUCTION.

The purpose of this chapter is to describe in detail how to "take off" material quantities (concrete, form and steel quantities) in one operation from construction plans and to follow these quantities through a systematic routine of unit pricing to the summary which gives final erection costs of a structure.

A typical example of "taking off" quantities from the plans and assigning unit prices is given for an interior bay 20 x 20 feet of a reinforced concrete building. The details accompanying this text are representative of plans that are furnished by architects to contractors for estimating costs and placing bids of erection complete.

The "take off" must necessarily follow certain structural divisions, as the unit items upon which it is possible to place a price vary with different parts of the structure as (1) footings, (2) columns (exterior and interior columns listed separately as they vary structurally) and (3) floor construction (divided into slabs, beams and girders because the prices of concrete, form and steel units vary with these members).

The pricing units, such as the cubic foot or yard of concrete, the square foot of contact area for the forms and the pound for the steel, must also be observed. It is customary to keep each floor separate as an aid to checking.

In the summary of floor quantities consideration must also be given to the number of times each form can be used over without alteration. In the building illustrated in Fig. 135, the slab, beam and girder forms for the second and third floor are the same as the first, so the only form change is for erecting and stripping.

This same condition of using the forms over applies to the columns; but in most buildings column sizes change slightly and the cost of cutting the larger columns down to sizes required for the higher stories is slight. It is therefore usual to average the column erection, stripping, and remaking as one amount.

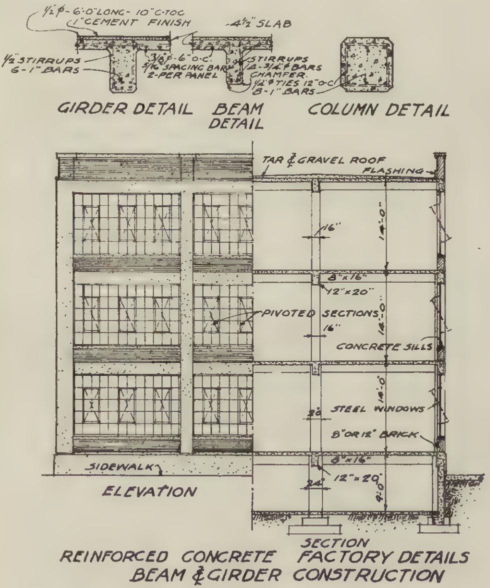


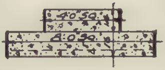
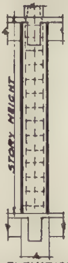
Fig 135—Typical Plan from which to make Estimate.

TAKE OFF SHEET
CONTRACTOR'S NAME

SHEET #1

DATE:

JOB: 3 STORY AND BSMT. FACTORY

	CONCRETE & FORMS						STEEL					
FOOTINGS	8'-0	8'-0	1'-4		85		SIZE	No	LENGTH	WT.		
	4'-0	4'-0	1'-2		19		3/4 φ	24	7'-4	1.5	264	
		TOTAL CONC.			104	X	1	8	3'-0	2.67	64	
	8'-0	4	1'-4		43				TOTAL STEEL		328	X
	4'-0	4	1'-2		19							
		TOTAL FORMS			62	X						
COLUMMS — BSMT	2'-0	2'-0	9'-4		32		1	8	10'-10	2.67	232	
 ELEVATION		TOTAL CONC			32		1/4	10	7'-6	.16	12	
 SECTION	2'-0	4	9'-4		75					STEEL	244	
		TOTAL FORMS			75							
FIRST	1'-8	1'-8	13'-7½		38		7/8	8	15'-0	2.04	245	
			CONC.		38		1/4	14	6'-6	.16	15	
	1'-8	4	13'-7½		91					STEEL	260	
			FORMS		91	X						
SECOND	1'-4	1'-4	13'-7½		24		7/8	4	15'-0	2.04	123	
			CONC		24		1/4	14	4'-6	.16	11	
	1'-4	4	13'-7½		73					STEEL	134	
			FORMS		73							
THIRD	1'-4	1'-4	13'-7½		24		3/4	4	14'-0	1.5	84	
			CONC		24		1/4	14	4'-6	.16	11	
	1'-4	4	13'-7½		73					STEEL	95	
			FORMS		73							
	TOTAL CONC. IN COLS				123	X	TOTAL STEEL IN COLS.				733	X
	TOTAL FORMS				312	X						
FIRST FLOOR SLAB	20'-0	20'-0	0'-4½		150		3/8	40	23'-0	.37	347	
			CONC.		150		5/16	6	23'-0	.26	37	
	20'-0	20'-0	1		400				STEEL		384	
			FORMS		400							
FIRST FLOOR BEAMS	0'-8	1'-4	20'-0	3	53		3/4	2x3	22'-6	1.5	203	
			CONC.		53		3/4	2x3	25'-3	1.5	228	
	2	1'-4	20'-0	3	160		3/8	18x3	3'-3	.37	67	
			FORMS		160				STEEL		498	
FIRST FLOOR GIRDERS	1'-0	1'-8	20'-0		34		1	3	23'-3	2.67	187	
			CONC.		34		1	3	27'-0	2.67	216	
	2	1'-8	20'-0		67		1/2	18 20	5'-0 6'-0	.67	60 80	
			FORMS		67				STEEL		543	
	TOTAL CONC. IN FLOOR				237		TOTAL STEEL IN FLOOR				1425	
SECOND FLOOR SAME AS FIRST												
THIRD " "	"	"										
ROOF	FORMS SAME AS 1ST						3/8	30	23'-0	.37	260	
	CONCRETE						5/16	20	23'-0	.26	120	
	20'-0	20'-0	0'-3½		117		3/4	3	22'-6	1.5	101	
	0'-8	1'-4	20'-0	3	53		3/4	3	25'-3	1.5	114	
	1'-0	1'-8	20'-0		34		3/8	14x3	3'-3	.37	51	
			CONC.		204		7/8	2	25'-0	2.04	94	
							7/8	2	26'-9	2.04	109	
							1/2	14	5'-0	.67	47	
							1/2	10	6'-0	.67	40	
									STEEL		936	
	TOTAL CONC. 1:2:3½ R				922		TOTAL STEEL 1:2:3½ R				5211	

INDICATES THE CONCRETE QUANTATIES TAKEN OF IN THIS PART OF ESTIMATE

INDICATES FORM QUANTATIES FOR SAME.

PRICING SHEET

CONTRACTOR'S NAME

SHEET # 2

DATE.

JOB: 3 STORY AND B'SMT. FACTORY

ITEM	QUANTITY	UNIT	MATERIAL	LABOR
FOOTINGS CONCRETE MATERIALS*	104 1/27 CU.YD.	4.78	18.41	
LABOR	"	1.50		5.77
FORMS LUMBER †	62 x 1/2 B.F.	.02	.62	
LABOR	62 SQ.FT.	.08		4.96
STEEL MATERIALS	328 LBS.	.04	13.12	
LABOR	328 "	.00 3/4		2.46
			32.15	13.19
COL'S. CONCRETE MATERIALS	123 x 1/27 CU.YD.	4.78	21.77	5.69
LABOR	"	1.25		
FORMS LUMBER	91 x 4 B.F.	.03	10.92	
LABOR	312 SQ.FT.	.10		31.20
STEEL MATERIALS	733 lbs	.04	29.32	
LABOR	733 "	.00 3/4		5.53
			62.01	42.42
FLOORS CONCRETE MATERIALS	922 x 1/27 CU.FT.	4.78	163.23	
LABOR	"	1.25		42.69
FORMS LUMBER	400 x 6 B.F.	.03	72.00	
LABOR MAKING 1ST FL. SLABS	400 SQ.FT.	.05		20.00
" " BEAMS	160 "	.12		19.20
" " GIRDER	67 "	.10		6.70
ERECTING 1ST FL.	400 "	.07		28.00
STRIPPING " "	400 "	.04		16.00
ERECTING & STRIPPING 2-3 & RF.	1200 "	.08		96.00
STEEL MATERIALS	5211 LBS.	.04	208.44	
LABOR	5211 "	.00 3/4		39.09
			443.67	267.68
PLANT FOR ABOVE				
CONCRETE-FOOTING 104 MAT.	1149 x 1/27 CU.YD.	.25	10.64	
COL 123, FLOORS 922 LABOR	" "	.10		4.25
1149				
LUMBER 62 x 1/2 31				
FORM CLAMPS 91 x 4 436 MAT.	2795 B.F.	.00 1/4	6.99	
400 x 6-2400				
2795				
STEEL TIE WIRES & CHAIRS	6372 LBS.	.00 3/4	4.78	
328, 733 MAT.			22.41	4.25
5211				
6372				
FINAL TOTALS			560.24x	327.54x

SUMMARY SHEET

CONTRACTOR'S NAME

DATE.

JOB: 3 STORY AND B'SMT. FACTORY

ITEM	MATERIAL	LABOR	TOTALS
TOTALS FROM PRICING SHEET	560.24	327.54	887.78
GENERAL EXPENSE. MAT. 10% OF	88.78		
LABOR 5% " "		44.39	
	649.02	371.93	
CONTINGENCIES 10% OF TOTAL LABOR		37.19	
	649.02	409.12	1058.14
PROFIT 5%			52.91
BID			$1111.05
SHEET # 3			

Sometimes more than one full set of floor forms is necessary to speed up the work and the quantities for making and erecting are increased proportionately.

Explanation of Schedule Sheets

Sheet No. 1—"Take off sheet" is the systematic tabulation of (1) quantities of concrete, (2) surface contact area of forms and (3) pounds of steel as taken from the plans furnished by the architect. All dimensions are taken off in feet and inches and the totals obtained in the unit upon which prices for the material required are obtained (concrete—cubic yards; forms—in square feet of contact area, and steel in lineal feet of different sizes to be reduced to pounds).

Sheet No. 2—"Pricing Sheet" is the systematic tabulation of quantities obtained from the totals of sheet No. 1 for the different structural divisions of the structure and the assigning of prices to these totals. Note that in assigning prices to these quantities there are two separate divisions—material costs and labor costs. It is well to maintain this division throughout the estimate schedule. Preliminary quotation can be obtained on material prices, but the labor cost is uncertain and should be carefully estimated and conservatively priced.

Sheet No. 3—"Summary Sheet" is the grouping of the totals from the pricing sheet No. 2 and the assigning of percentage to material and labor costs for general job expenses, contingencies and profit. The total of summary items gives bid price for the job.

PORTLAND CEMENT

Concrete dates back to the Romans. They secured good results with concrete made of a mixture of slaked lime, volcanic dust, sand and broken stone. This combination, though crude in comparison with the Portland cement concrete of the present day, produced an artificial stone which has stood the test of nearly 2,000 years. Many works and roads of concrete built in Italy and southern France long ago are today in a fine state of preservation.

Portland cement is of modern origin. Joseph Aspdin, of Leeds, England, took out a patent under date of December 15th, 1824, for the manufacture of Portland cement. It was so called because it resembled in color a well-known limestone quarried on the Island of Portland, which was then considered the hardest stone known. The manufacture of Portland cement was begun in 1825, but the progress was slow until about 1850, when, through improved methods and general recognition of its merits as a building material, its commercial success was assured.

About this time the manufacture of Portland cement was taken up by the French and Germans, and by reason of their more scientific methods, both the method of manufacture and the quality of the finished product was greatly improved. The first German Portland cement works were built in Stettin in 1855.

Portland Cement in America

Portland cement was first brought to the United States in 1865 and was first manufactured in this country in 1872.

The advance of the American Portland cement industry during the last decade has been one of the marvels of the age. From a very small beginning the Americans came very rapidly to the front and with improved methods and appliances forged ahead until today the American Portland cements are superior to any others in the world. Not only this, but the section of the State of Pennsylvania,

in which our Northampton Mill is located, produces more Portland cement today than all Germany and England combined.

In the early days in Germany and England, as well as in the United States, Portland cement was burned in dome kilns, much like those used for burning lime, the mixture in various stages being put into these kilns with alternate layers of coal or coke. The output of such a kiln was seldom more than 100 barrels a day. This process was continued until the early nineties, when the Atlas Portland Cement Company began experimenting with a steel cylindrical tube, known as the rotary kiln. It was rapidly developed by this Company and is being used today for calcining Portland cement in every mill in the United States and is gradually being adopted in Germany and England. These rotary kilns produce from 500 to 3,000 barrels per day, according to their size. More than anything else they have been instrumental in reducing the cost of manufacture to such an extent as to make Portland cement an economical building material.

Modern Portland cement is a chemical compound. It is manufactured from a mixture of two materials, one a limestone or a softer material like chalk, which is nearly pure lime, and second, shale, which is like clay, or else clay itself. Portland cement can be manufactured anywhere that these ingredients are found. But it cannot be manufactured without the one material which is largely limestone, and the other material which is largely clay, and the two materials must be mixed in very exact proportions determined by tests, the proportions being changed as often as necessary to allow for any variation in the chemical composition of the materials. In the Lehigh Valley, Pennsylvania, where a substantial proportion of the entire output of the country is manufactured, there are extensive natural deposits of what is known as cement rock, which contains the ingredients needed in practically the proper proportions for the manufacture of Portland cement.

To manufacture Portland cement the raw materials are quarried, crushed and pulverized, mixed in the proper proportions, and the pulverized raw materials of the correct chemical composition are then fed into rotary kilns, where the mixture is burned to what is known as cement clinker.

Briefly described, a rotary kiln is a steel cylinder 6 to 12 feet in diameter and from 60 to 250 feet in length. It is continuous in operation—the raw material is fed into one end and by reason of the inclined position of the kiln and its rotary motion, the material is passed into the lower end and discharged. During the passage of this raw material from one end of the kiln to the other, perfect calcination is obtained by means of an air blast, carrying powdered coal, the coal being set on fire as it enters the kiln. The clinker resulting from the burning of the raw material in this way is then cooled and pulverized and becomes the Portland cement of commerce.

ATLAS PORTLAND CEMENT

Wonderful as the advance of the general industry has been, the growth of The Atlas Portland Cement Company has been even more remarkable. Beginning in 1892 at Coplay, Pennsylvania, with a manufacturing capacity of 250 barrels per day, its production has steadily increased through the various plants at Northampton, Pa., Hannibal, Missouri; Hudson, New York; and Leeds, Alabama; until now the productive capacity of The Atlas Portland Cement Company is more than fifty thousand barrels each day, or approximately eighteen millions a year—with a storage capacity of over four million barrels. The locations for The Atlas plants were made with two points in view, the primary consideration being proximity to the best known raw materials, and the secondary advantages from a trade standpoint. At Northampton the plant now covers about 30 acres of ground, and a fence built closely around the entire plant would enclose about

60 acres. When in full operation, the Northampton plant consumes about 9,000 tons of raw rock, and 2,000 tons of coal per day, and employs 4,500 men. These figures, which concern the Northampton plant alone, give an idea of the capacity of the Atlas plants as a whole. By virtue of its enormous production The Atlas Portland Cement Company is able to develop and retain in its service the most skilled operating talent in the Portland cement industry, which insures in Atlas a thoroughly reliable and uniform product.

The methods of manufacture of Portland cement developed and perfected by The Atlas Portland Cement Company have been continued with the greatest care and to such an extent that these methods are accepted as standard by practically every other cement manufacturing company. In the manufacture of Atlas Portland Cement, the raw materials are carefully selected, and carefully mixed after automatic weighing machines have weighed exactly the right quantity of cement rock and the right quantity of limestone. These materials are then mixed thoroughly by automatic mixers, which are constantly controlled by chemists in charge of the operation, not only during the day but night and day. With this control, the mixture never varies. In fact, at the Atlas plants from the time the rock is quarried until the cement is packed into bags and barrels, the work is done by machinery controlled in all its stages by experts. In plain words, we manufacture cement scientifically and not by accident. The finished product also is constantly tested and the mill never operates for a moment without the control of the mill chemists.

One grade of cement only—the highest—is manufactured, and every barrel shipped from the Atlas mills meets all standard specifications for Portland cement, and also complies with Atlas specifications, under which each of our mills operates and which are more severe and more exacting than the requirements of standard specifications.

ATLAS-WHITE NON-STAINING PORTLAND CEMENT

Atlas-White Portland Cement is a true Portland Cement. Its chemical composition is practically identical with that of Atlas Portland Cement. The strength of Atlas-White is equal to that of Atlas Gray, and is guaranteed to meet the standard requirements for Portland Cement. It is, therefore, a true Portland Cement that has the same physical characteristics as the gray Atlas, and may be used with the same manipulation and for the same class of work where a white color is desired.

Atlas-White was placed on the market for the purpose of supplying the demand for a high-grade white Portland Cement that was non-staining and could be used where a white or light tone effect of coloring was wanted. Its non-staining property makes it desirable for setting and pointing fine textured stone as marble, light granite, etc. It will not stain or streak these natural rocks, and they are as firmly cemented together when bedded or set in Atlas-White as if they were one solid stone.

Atlas-White is also used in all colored cement work where true color tones are desired. It is white, and therefore gives the true color value of color aggregates or coloring pigments. In all decorative cement work, either exterior or interior, Atlas-White has afforded the opportunity of color and soft tone effects never before realized in cement construction.

The use of Atlas-White for colored stucco and other purposes is explained in detail in other booklets issued by the Atlas Portland Cement Company, and these will be furnished upon request to those who are interested and are contemplating stucco work. What is said in this book applies to problems in the use of Atlas-White, as well as to Atlas Portland Cement.

In using Atlas-White it should be remembered that if a pure effect is desired, it will be necessary to use an aggregate (usually sand) with it that is also white. In some

localities it is difficult to find sand of a satisfactory quality or color to mix with Atlas-White Portland Cement. To obviate this difficulty the Atlas Portland Cement Company manufactures Atlas-White Mixture No. 1, Atlas-White Mixture No. 2, and Atlas-White No. 3. These are mixtures of Atlas-White Portland Cement and selected white sand, all ready to be used for mortars and facings.

Below is given a partial list of books published by The Atlas Portland Cement Company, any of which we will gladly send you if you will address our nearest office.

Cast Stone
Reinforced Concrete in Factory Construction
Industrial Plant Roadways
Industrial Houses of Concrete and Stucco
Oil Storage Tanks of Concrete
War Memorials
Mortar for Pointing, Setting and Backing
Guide to Good Stucco
Information for Home Builders
Building a Bungalow
Choosing the Garage
New Homes for Old
Concrete on the Farm
Concrete on the Farm in Cold Weather

THE ATLAS PORTLAND CEMENT COMPANY
New York Chicago Philadelphia Boston St. Louis
Des Moines Dayton Birmingham

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